US 20110157169A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2011/0157169 A1

(43) Pub. Date: Jun. 30, 2011

Bennett et al.

(54) **OPERATING SYSTEM SUPPORTING MIXED 2D, STEREOSCOPIC 3D AND MULTI-VIEW 3D DISPLAYS**

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(21) Appl. No.: **12/982,124**

(22) Filed: **Dec. 30, 2010**

**Related U.S. Application Data**

(60) Provisional application No. 61/291,818, filed on Dec. 31, 2009, provisional application No. 61/303,119, filed on Feb. 10, 2010.

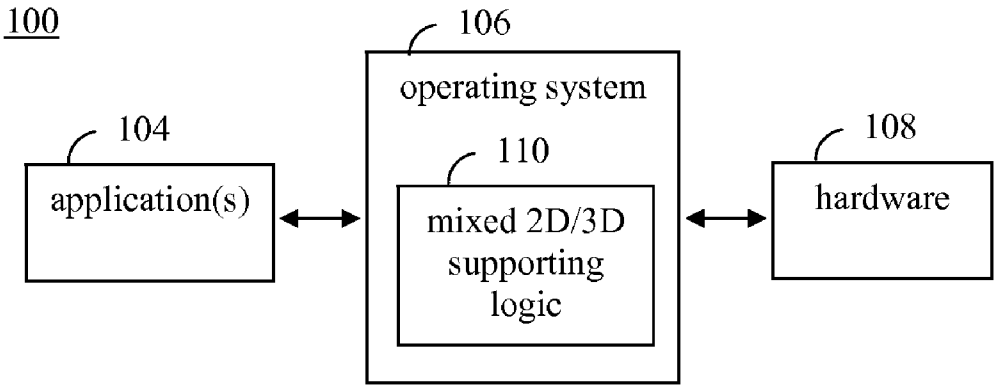
**Publication Classification**

(51) **Int. Cl.**
*G06T 15/00* (2011.01)

(52) **U.S. Cl.** ..... **345/419**

(57) **ABSTRACT**

Operating systems are described that interface applications and display screens capable of displaying two-dimensional and three-dimensional content. In one aspect, an operating system includes an application programming interface (API), a display driver interface, and a display driver. The API enables one or more applications to deliver requests that define a screen region and either a two-dimension indicator or a three-dimension indicator. The display driver interface passes configuration commands corresponding to the requests. The display driver is associated with a display screen. The display driver receives the configuration commands and responds by generating screen control signals to adjust the display screen to support the screen region.



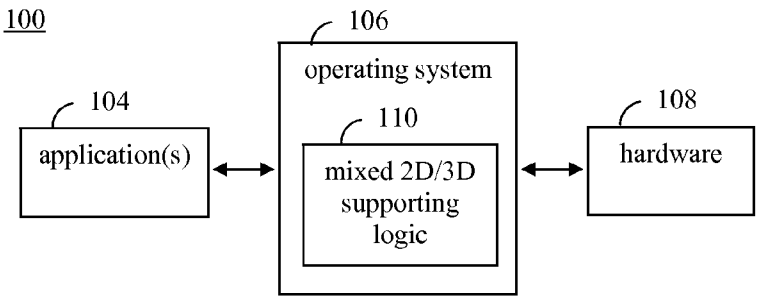



FIG. 1

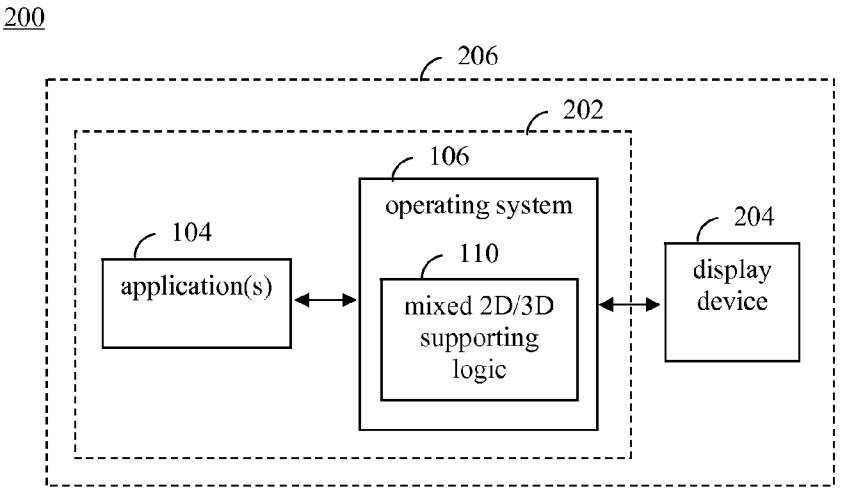



FIG. 2

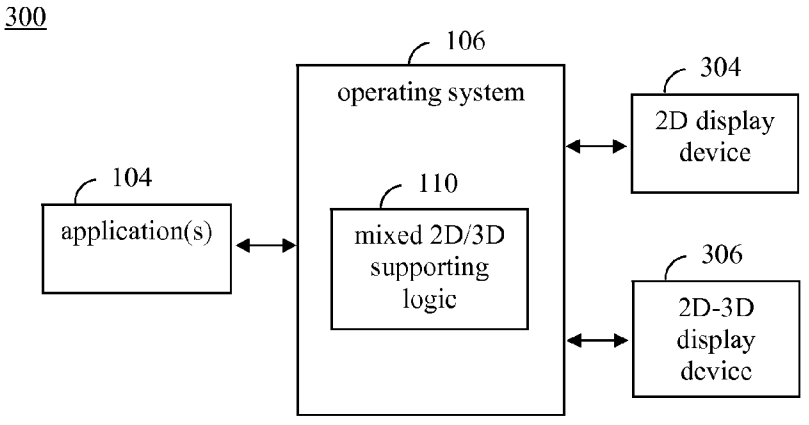



FIG. 3

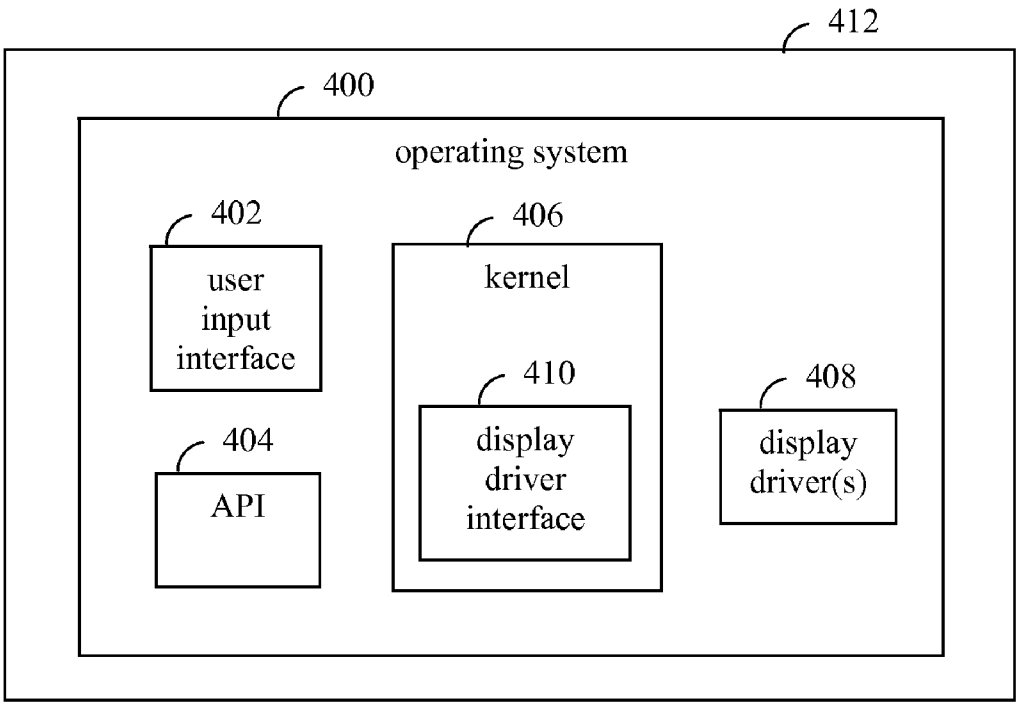

412
400
operating system
402
user input interface
406
kernel
410
display driver interface
408
display driver(s)
404
API

FIG. 4A

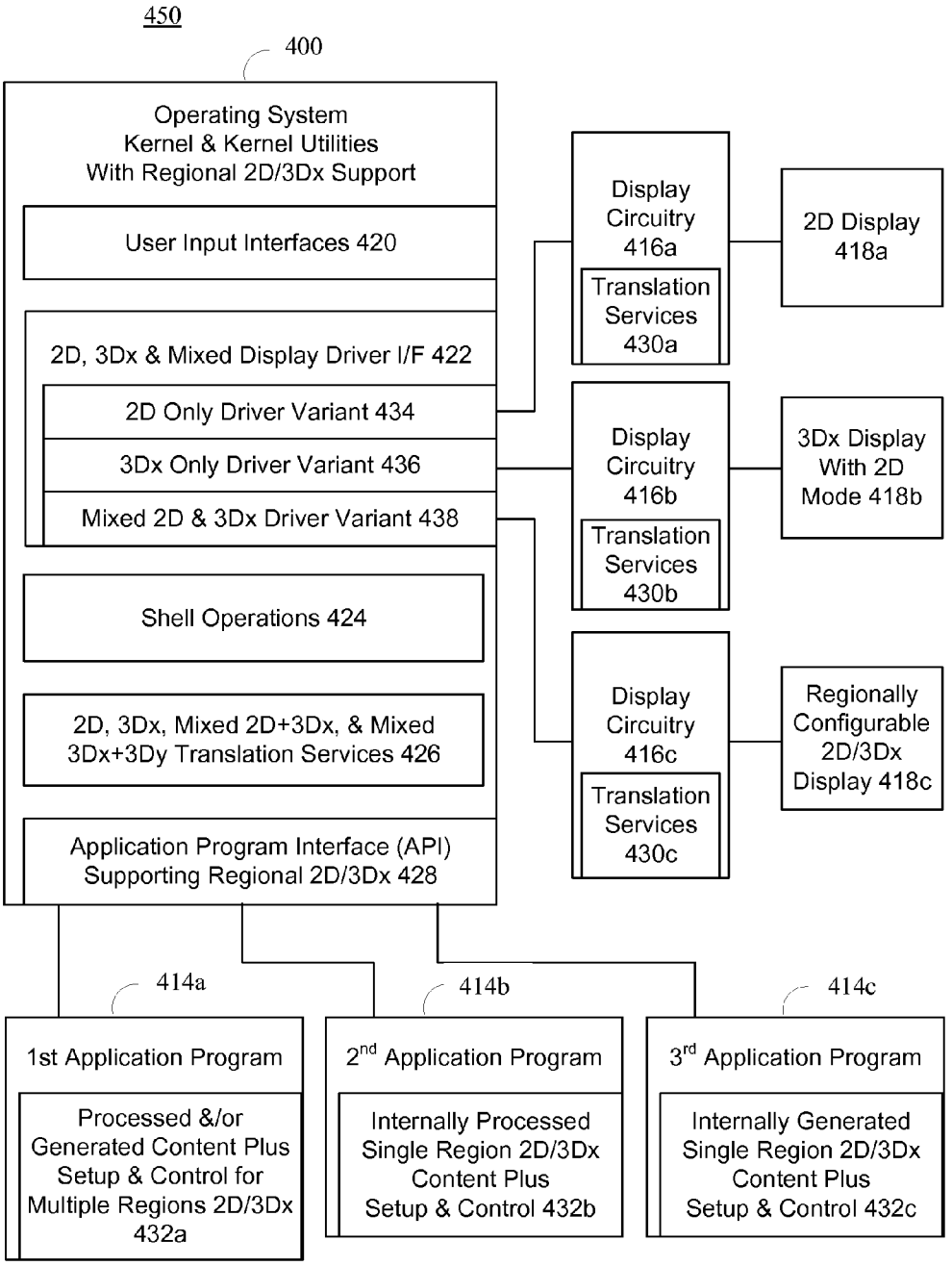

450
400
Operating System
Kernel & Kernel Utilities
With Regional 2D/3Dx Support
User Input Interfaces 420
2D, 3Dx & Mixed Display Driver I/F 422
2D Only Driver Variant 434
3Dx Only Driver Variant 436
Mixed 2D & 3Dx Driver Variant 438
Shell Operations 424
2D, 3Dx, Mixed 2D+3Dx, & Mixed 3Dx+3Dy Translation Services 426
Application Program Interface (API) Supporting Regional 2D/3Dx 428
Display Circuitry 416a
Translation Services 430a
2D Display 418a
Display Circuitry 416b
Translation Services 430b
3Dx Display With 2D Mode 418b
Display Circuitry 416c
Translation Services 430c
Regionally Configurable 2D/3Dx Display 418c
414a
414b
414c
1st Application Program
Processed &/or Generated Content Plus Setup & Control for Multiple Regions 2D/3Dx 432a
2nd Application Program
Internally Processed Single Region 2D/3Dx Content Plus Setup & Control 432b
3rd Application Program
Internally Generated Single Region 2D/3Dx Content Plus Setup & Control 432c

FIG. 4B

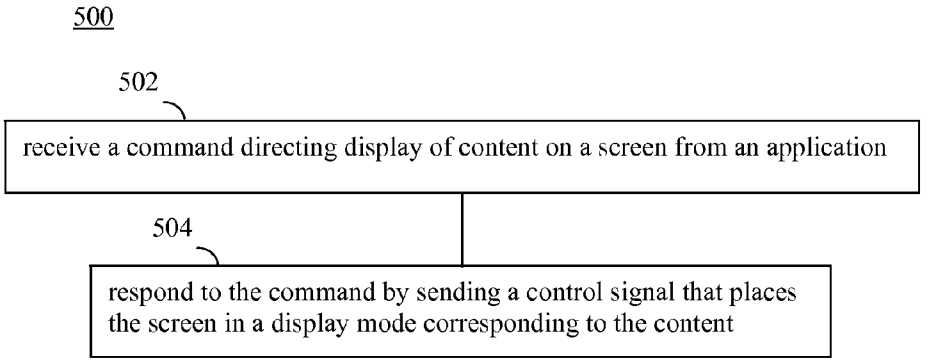



FIG. 5

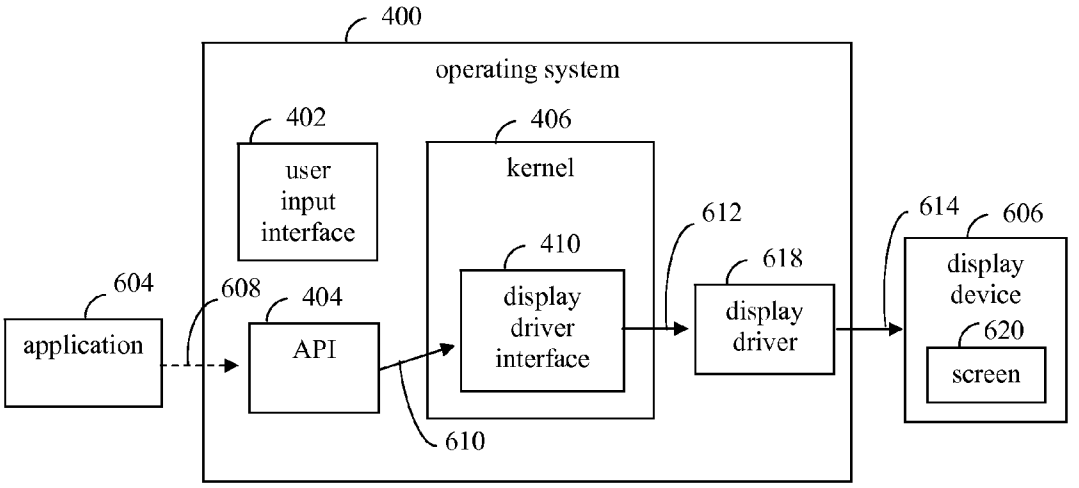



FIG. 6

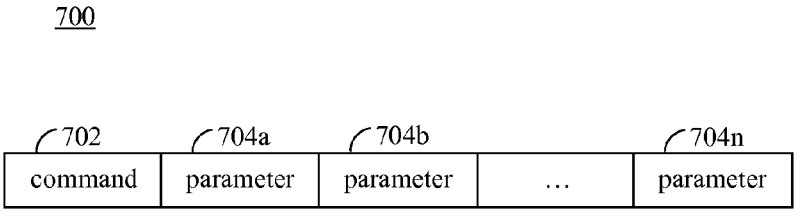



FIG. 7

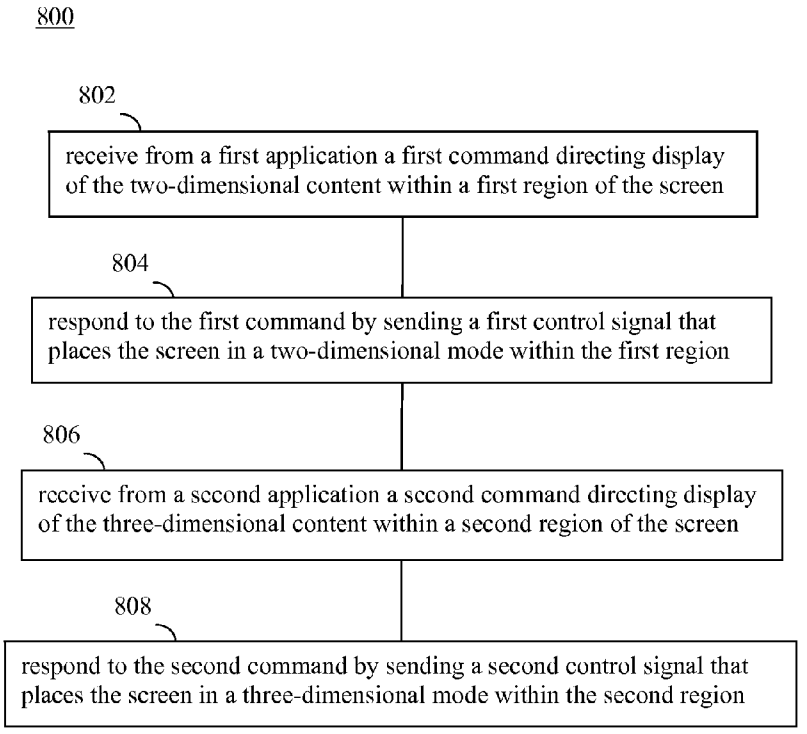

800
802
receive from a first application a first command directing display of the two-dimensional content within a first region of the screen
804
respond to the first command by sending a first control signal that places the screen in a two-dimensional mode within the first region
806
receive from a second application a second command directing display of the three-dimensional content within a second region of the screen
808
respond to the second command by sending a second control signal that places the screen in a three-dimensional mode within the second region

FIG. 8

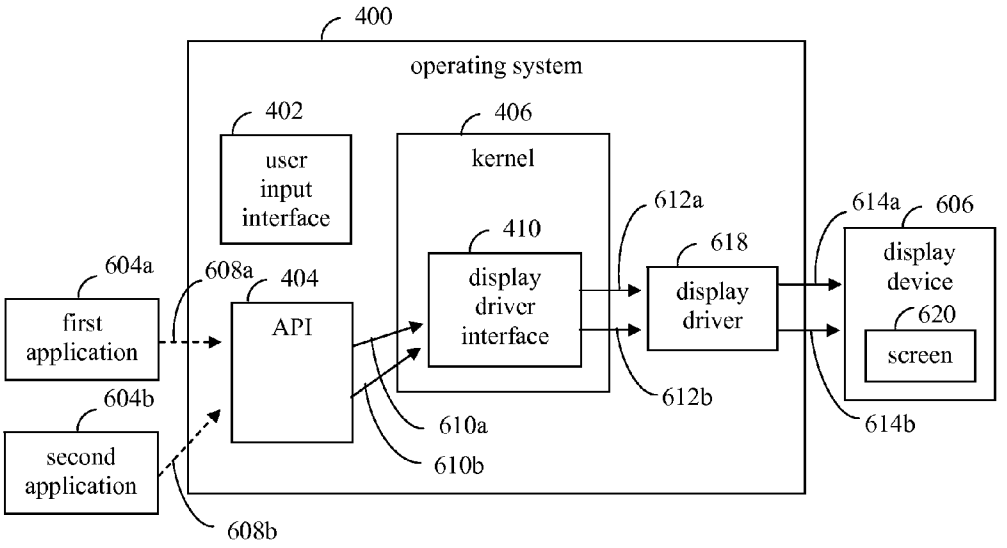

400
operating system
402
user input interface
406
kernel
410
display driver interface
404
API
604a
first application
604b
second application
608a
608b
610a
610b
612a
612b
618
display driver
614a
606
display device
620
screen
614b

FIG. 9

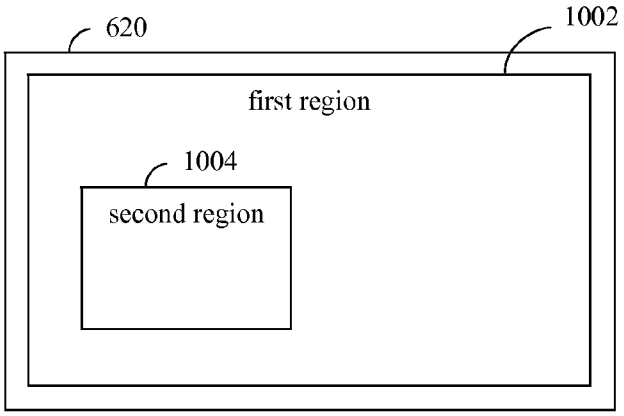



FIG. 10

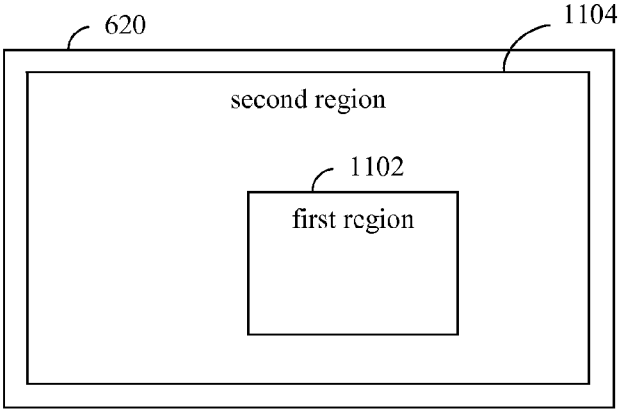



FIG. 11

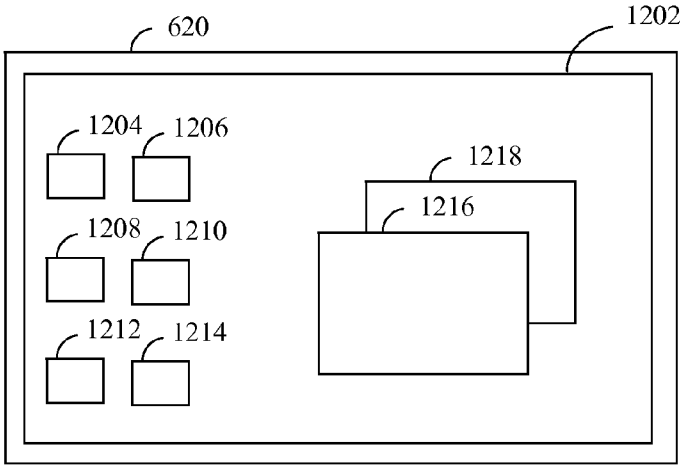



FIG. 12A

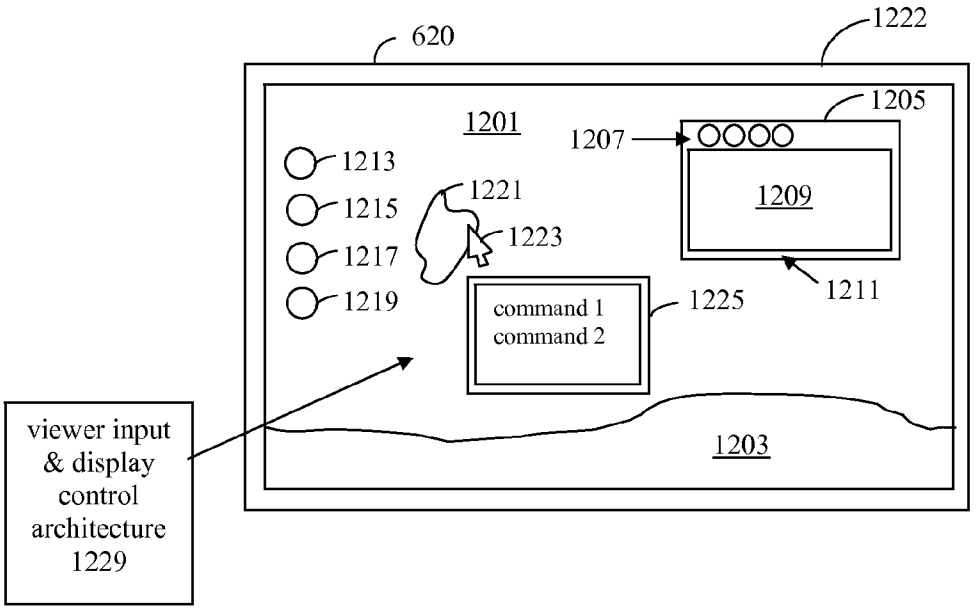

620
1222
1205
1201
1207
1213
1215
1217
1219
1221
1223
1209
1211
command 1
command 2
1225
1203
viewer input & display control architecture 1229

FIG. 12B

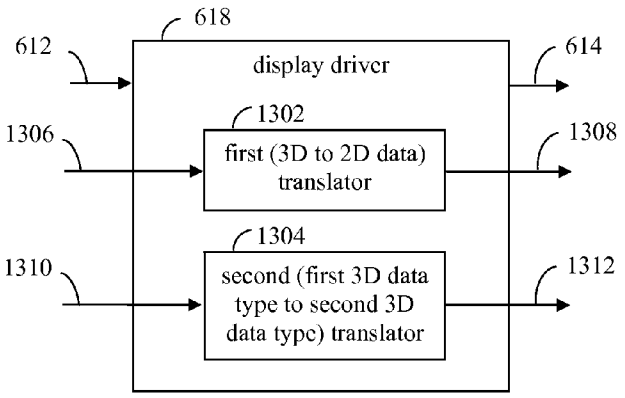



FIG. 13

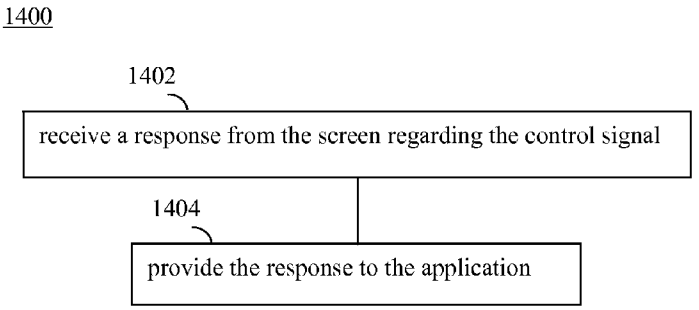



FIG. 14

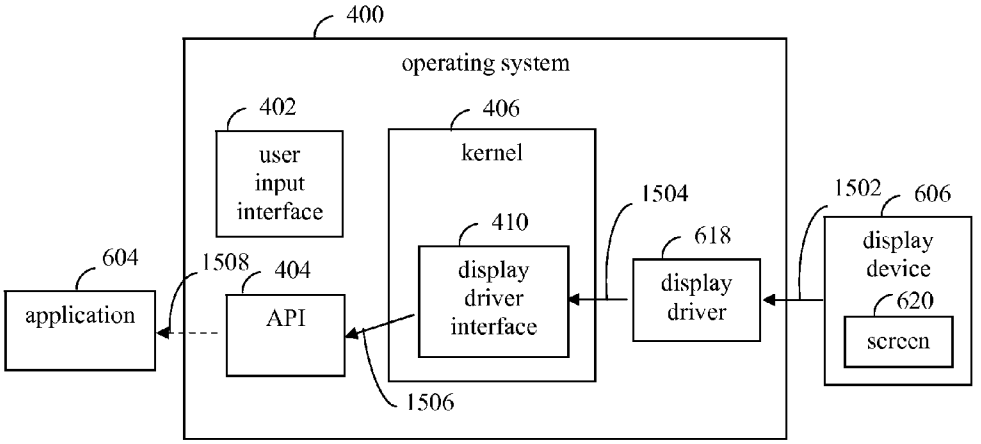



FIG. 15

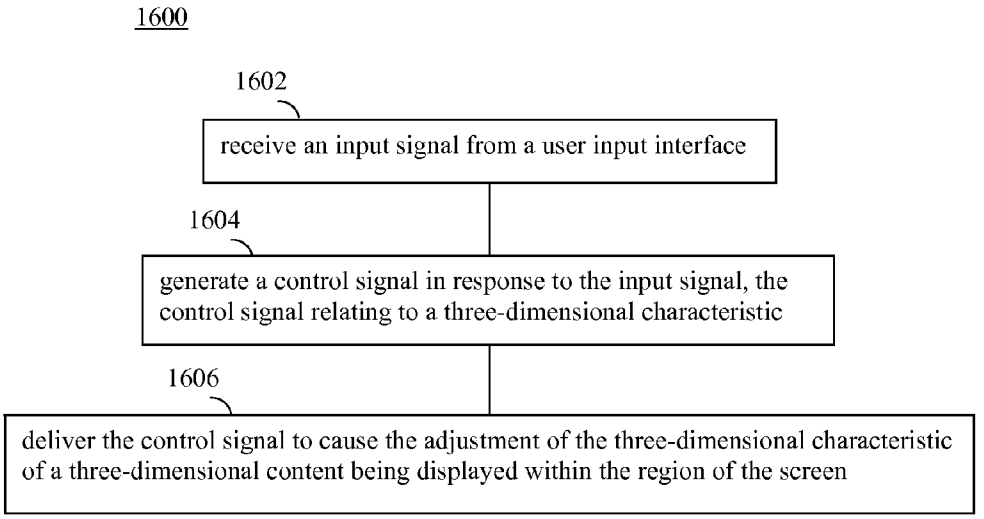

1600
1602
receive an input signal from a user input interface
1604
generate a control signal in response to the input signal, the control signal relating to a three-dimensional characteristic
1606
deliver the control signal to cause the adjustment of the three-dimensional characteristic of a three-dimensional content being displayed within the region of the screen

FIG. 16

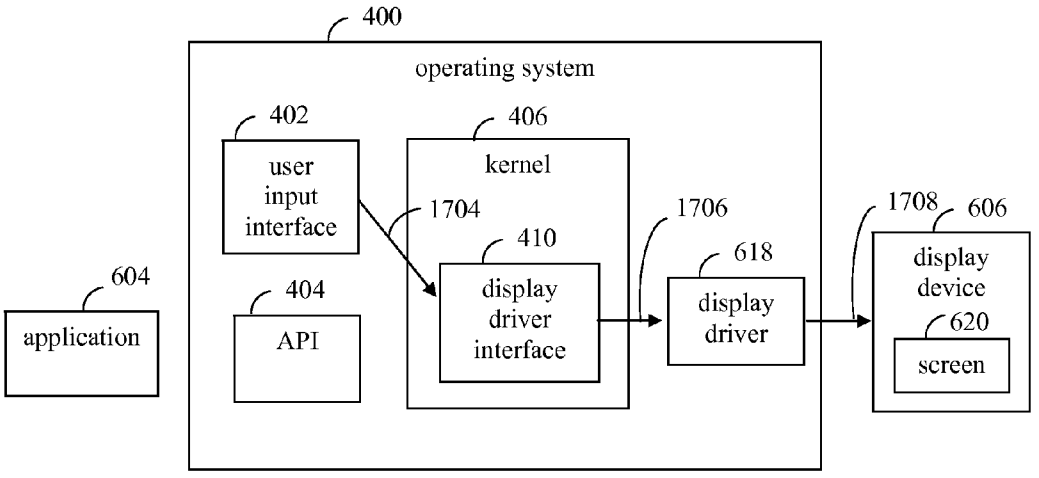

400
operating system
402
user input interface
406
kernel
1704
410
display driver interface
1706
618
display driver
1708
606
display device
620
screen
604
application
404
API

FIG. 17

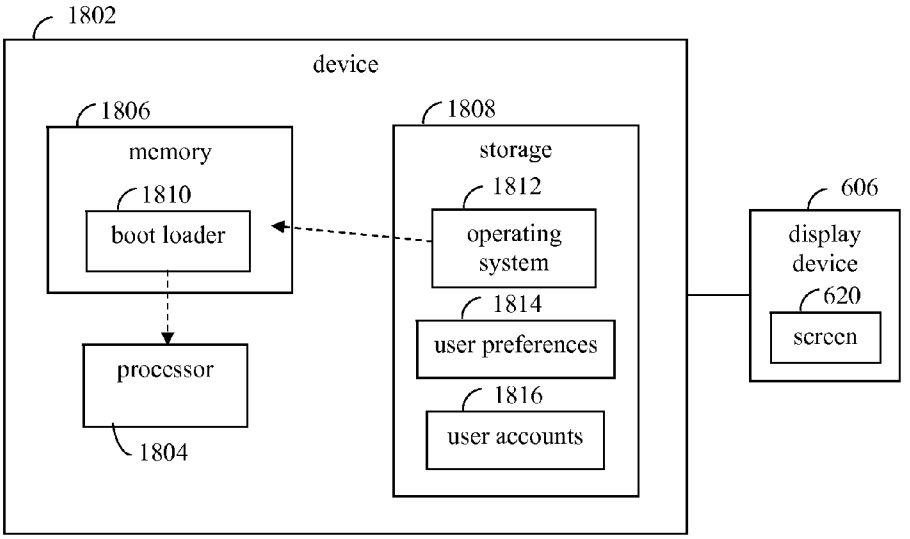

1802
device
1806
memory
1810
boot loader
processor
1804
1808
storage
1812
operating system
1814
user preferences
1816
user accounts
606
display device
620
screen

FIG. 18

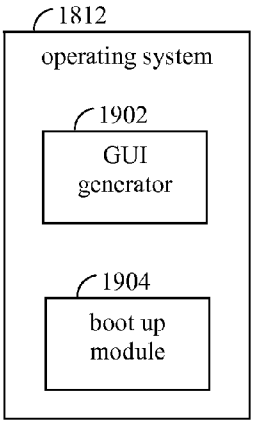

1812
operating system
1902
GUI generator
1904
boot up module

FIG. 19

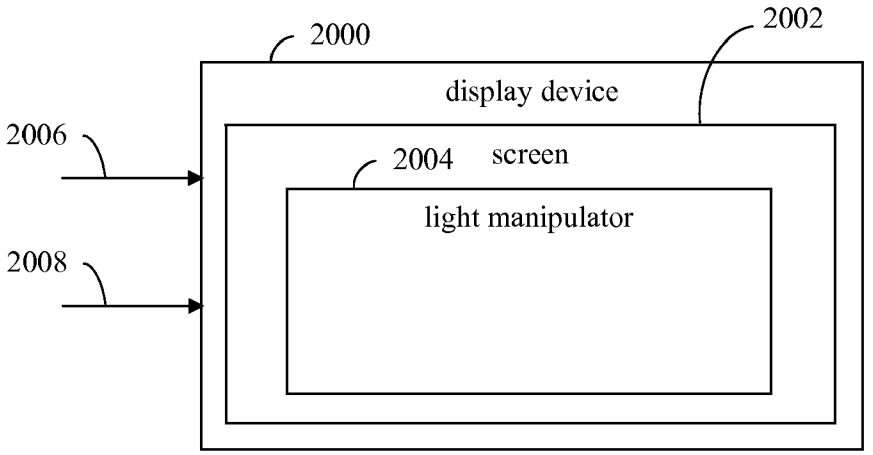

2000
2002
display device
2006
2004
screen
light manipulator
2008

FIG. 20

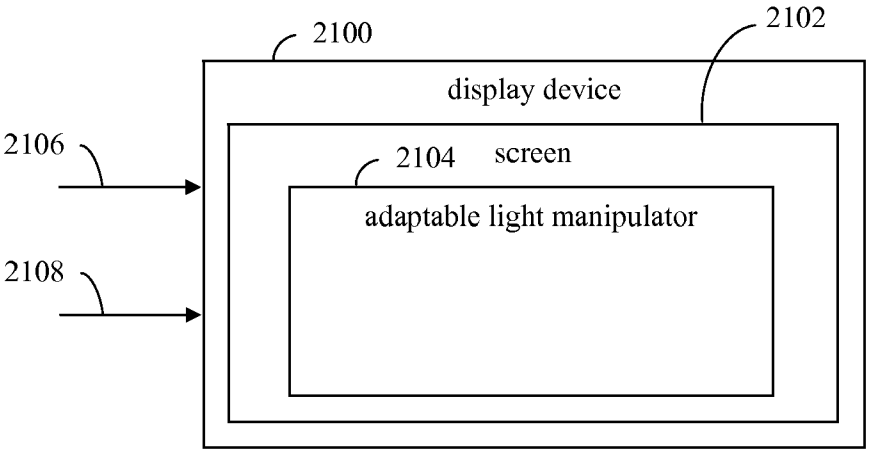

2100
2102
display device
2106
2104
screen
adaptable light manipulator
2108

FIG. 21

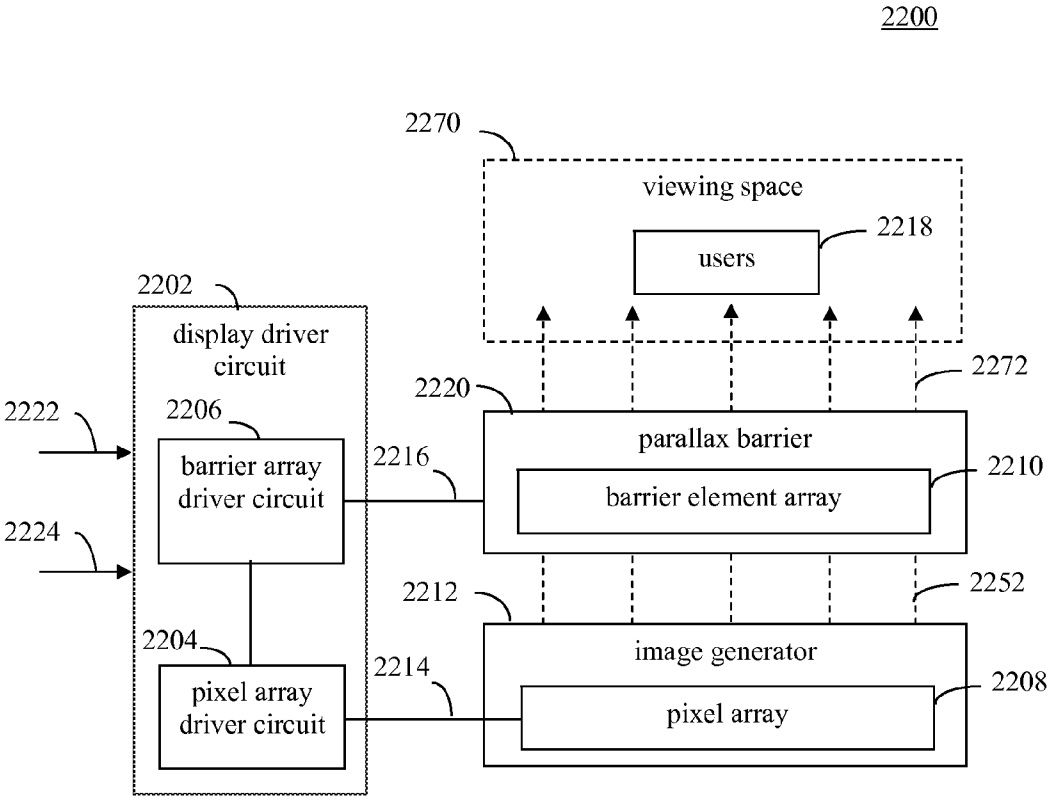

2200
2270
viewing space
2218
users
2202
display driver circuit
2222
2206
barrier array driver circuit
2216
2220
parallax barrier
2210
barrier element array
2272
2224
2212
2252
2204
image generator
2214
2208
pixel array driver circuit
pixel array

FIG. 22

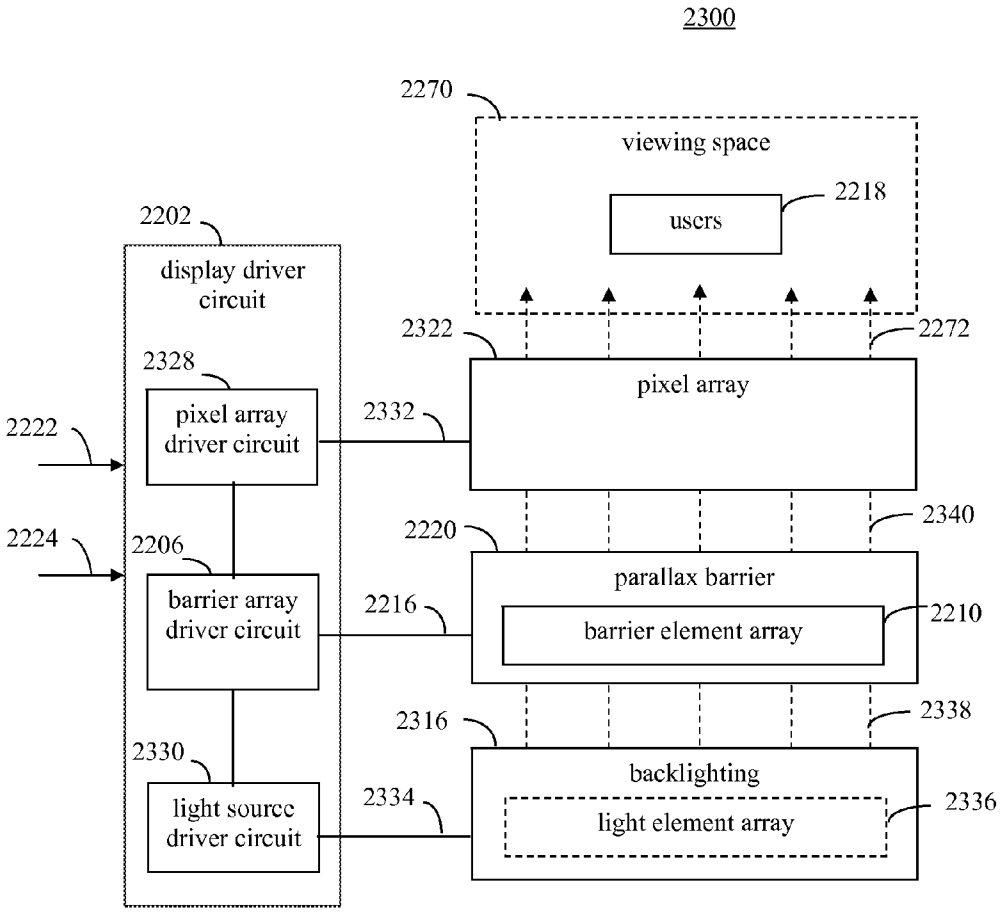

2300
2270
viewing space
2218
users
2202
display driver circuit
2322
2272
2328
pixel array
pixel array driver circuit
2332
2222
2340
2224
2220
2206
parallax barrier
barrier array driver circuit
2216
barrier element array
2210
2316
2338
2330
backlighting
2334
light source driver circuit
light element array
2336

FIG. 23

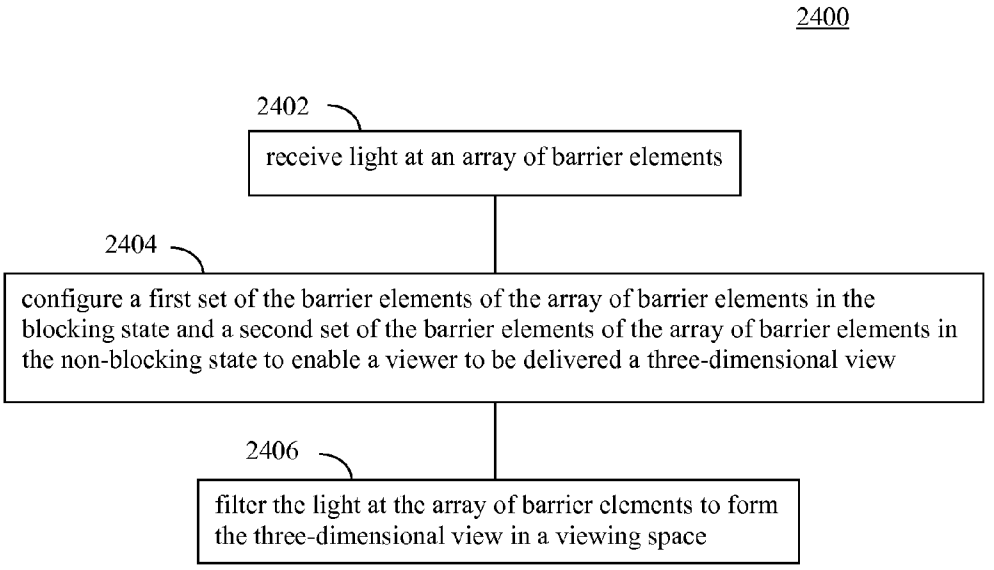

2400
2402
receive light at an array of barrier elements
2404
configure a first set of the barrier elements of the array of barrier elements in the blocking state and a second set of the barrier elements of the array of barrier elements in the non-blocking state to enable a viewer to be delivered a three-dimensional view
2406
filter the light at the array of barrier elements to form the three-dimensional view in a viewing space

FIG. 24

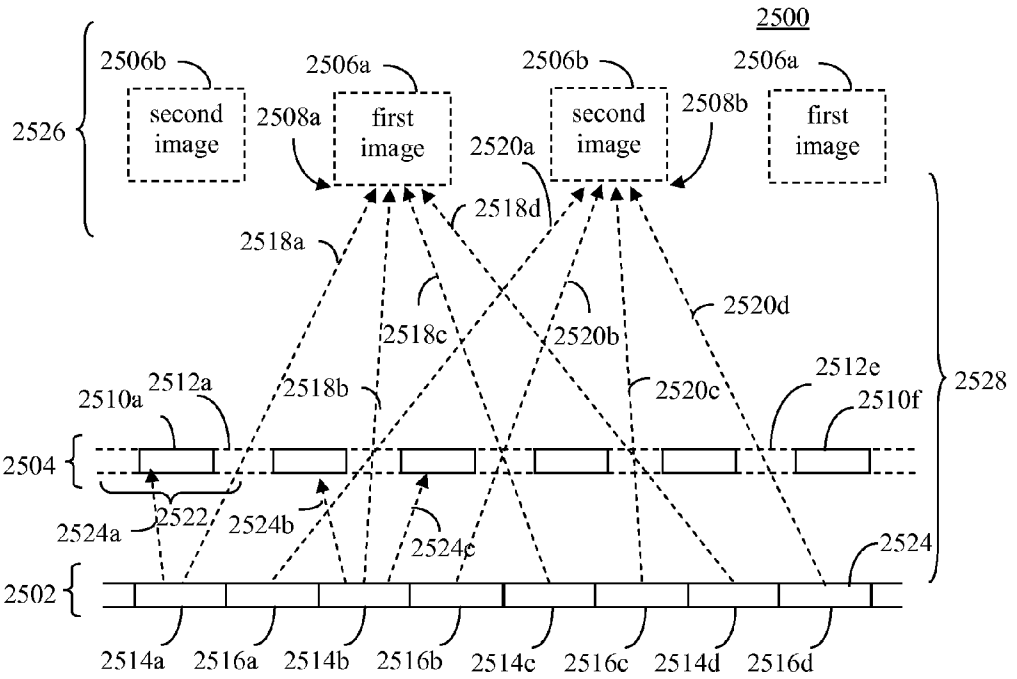

2500
2506b
2506a
2506b
2506a
second image
first image
second image
first image
2526
2508a
2508b
2520a
2518d
2518a
2520d
2518c
2520b
2512e
2528
2510a
2512a
2518b
2520c
2510f
2504
2522
2524a
2524b
2524c
2524
2502
2514a
2516a
2514b
2516b
2514c
2516c
2514d
2516d

FIG. 25

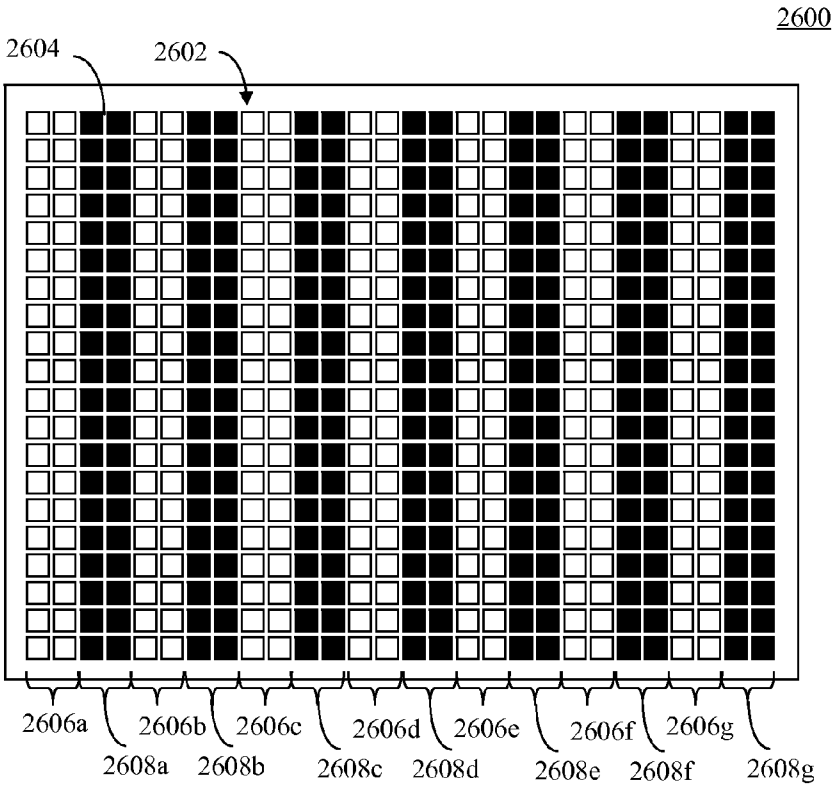

2600
2604
2602
2606a
2606b
2606c
2606d
2606e
2606f
2606g
2608a
2608b
2608c
2608d
2608e
2608f
2608g

FIG. 26

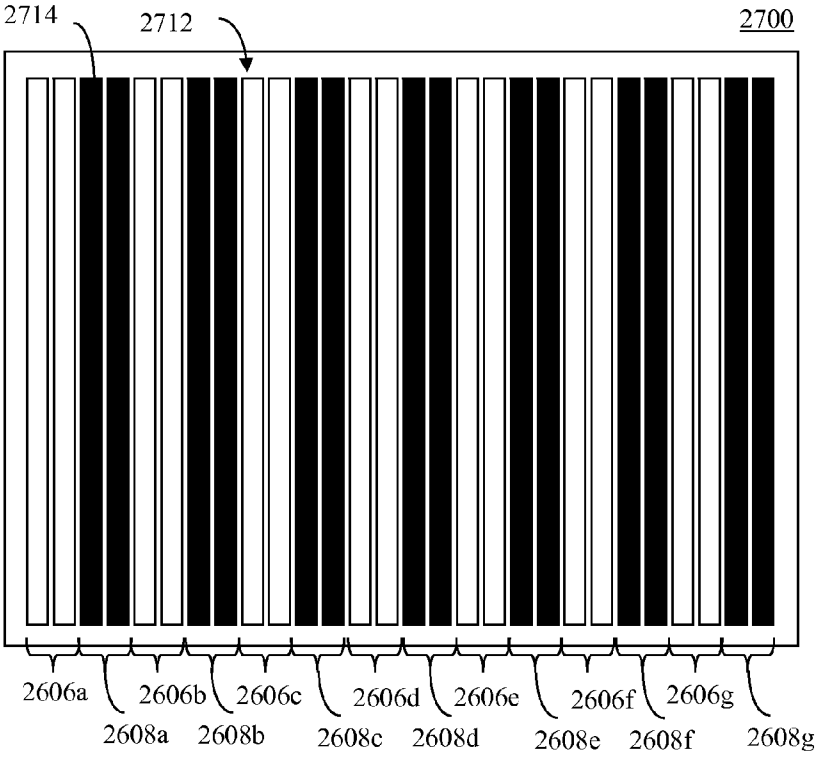

2714
2712
2700
2606a
2606b
2606c
2606d
2606e
2606f
2606g
2608a
2608b
2608c
2608d
2608e
2608f
2608g

FIG. 27

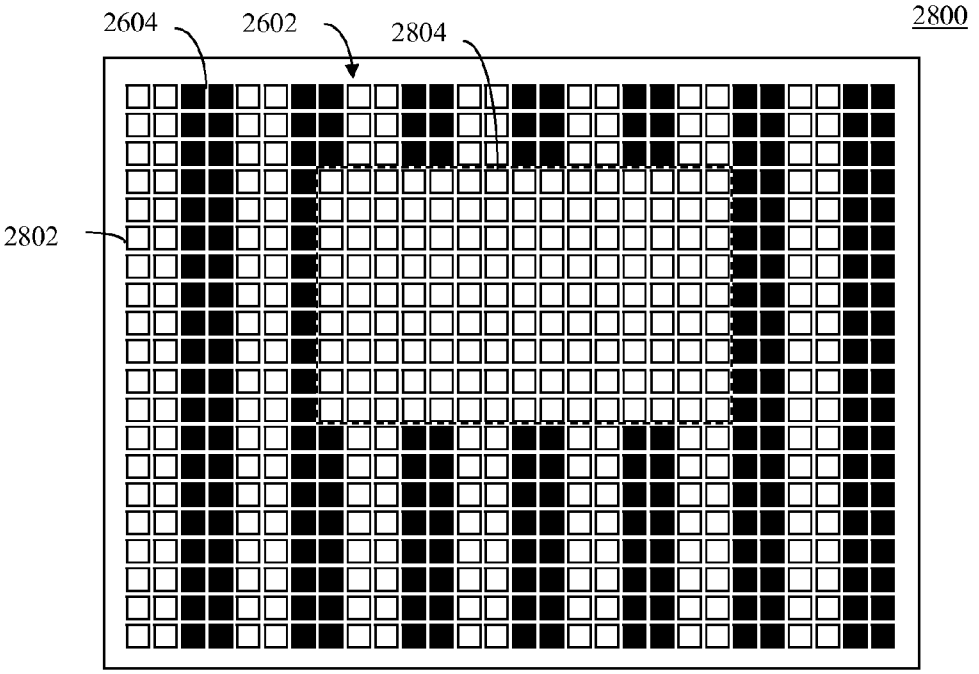

2604
2602
2804
2800
2802

FIG. 28

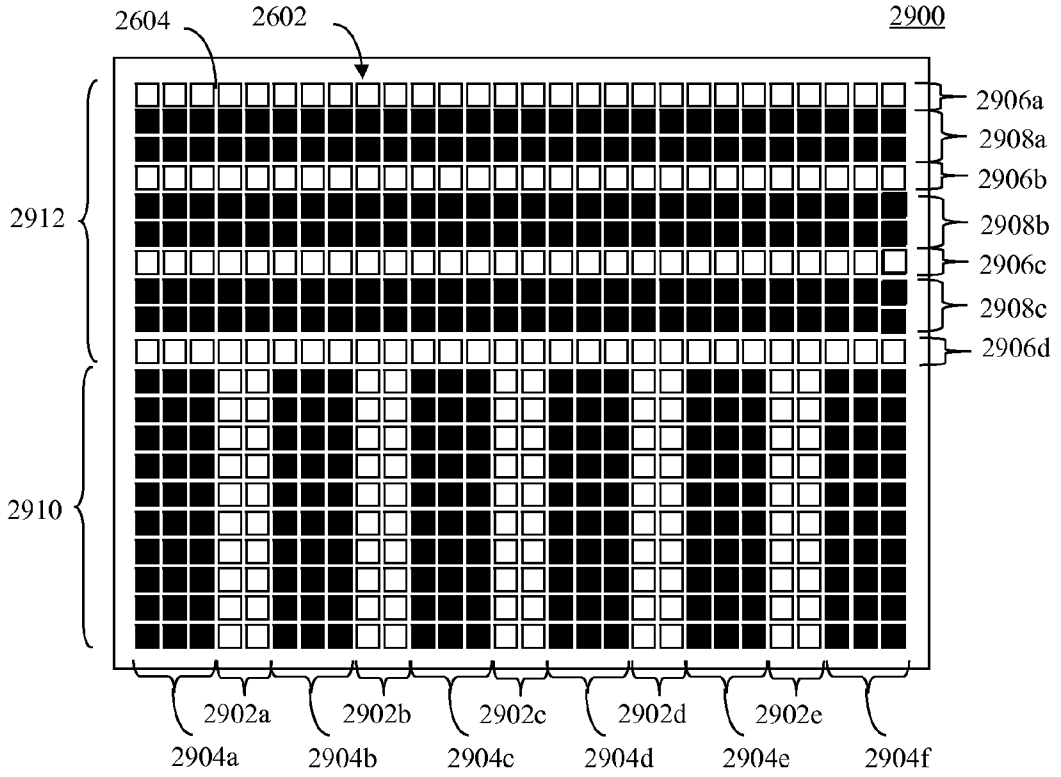

2604
2602
2900
2912
2910
2906a
2908a
2906b
2908b
2906c
2908c
2906d
2902a
2902b
2902c
2902d
2902e
2904a
2904b
2904c
2904d
2904e
2904f

FIG. 29

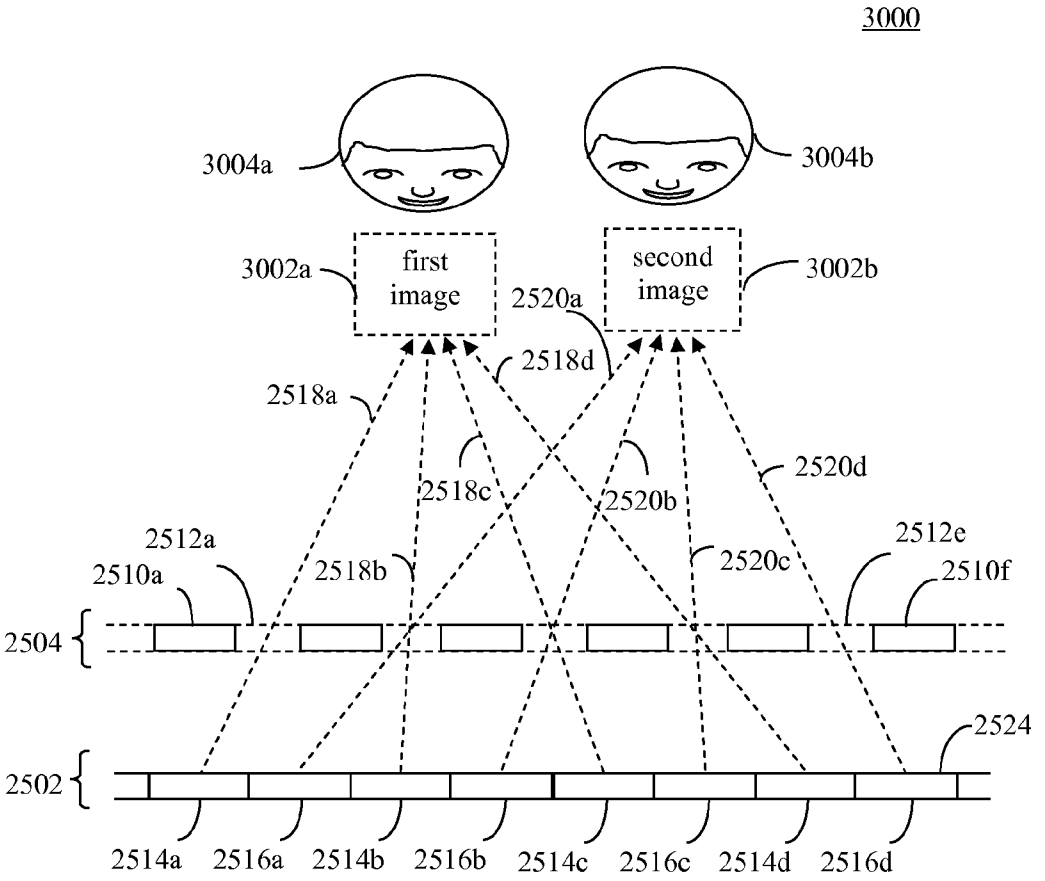

3000
3004a
3004b
3002a
first image
second image
3002b
2520a
2518d
2518a
2520d
2518c
2520b
2512a
2512e
2510a
2518b
2520c
2510f
2504
2524
2502
2514a
2516a
2514b
2516b
2514c
2516c
2514d
2516d

FIG. 30

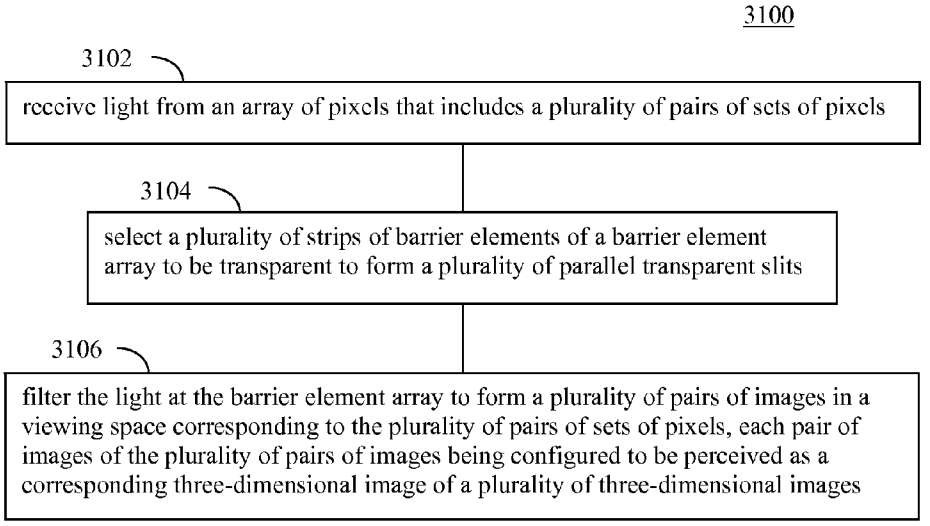

3100
3102
receive light from an array of pixels that includes a plurality of pairs of sets of pixels
3104
select a plurality of strips of barrier elements of a barrier element array to be transparent to form a plurality of parallel transparent slits
3106
filter the light at the barrier element array to form a plurality of pairs of images in a viewing space corresponding to the plurality of pairs of sets of pixels, each pair of images of the plurality of pairs of images being configured to be perceived as a corresponding three-dimensional image of a plurality of three-dimensional images

FIG. 31

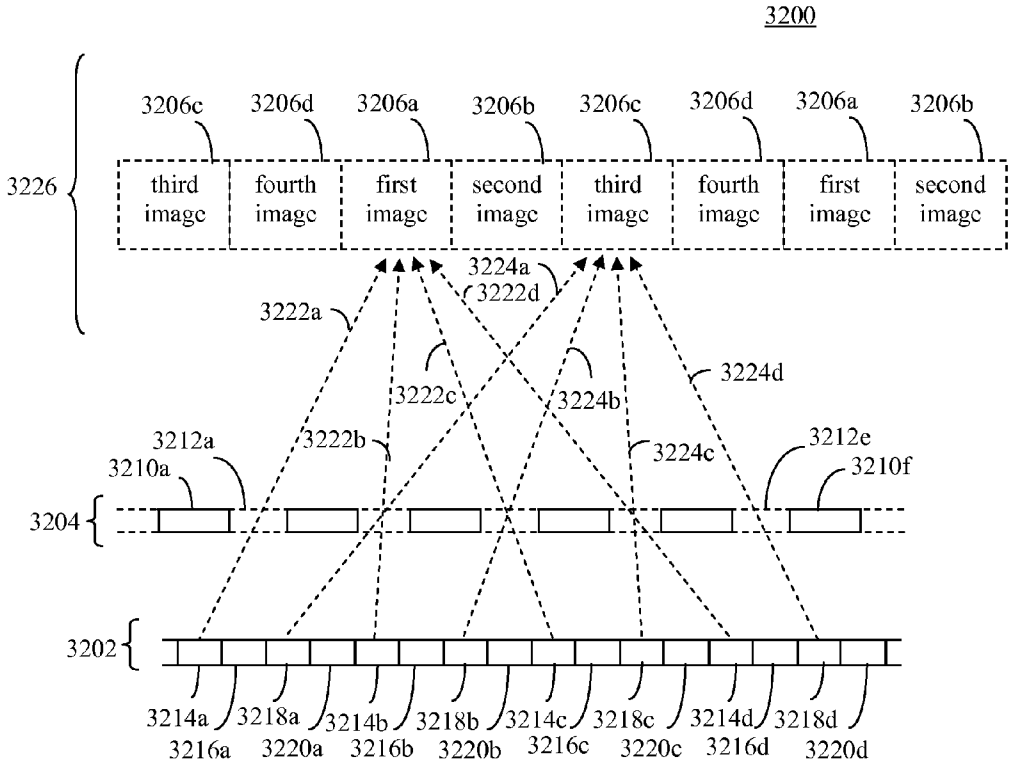

3200
3226
3206c 3206d 3206a 3206b 3206c 3206d 3206a 3206b
third image
fourth image
first image
second image
third image
fourth image
first image
second image
3224a
3222d
3222a
3222c
3224b
3224d
3224c
3222b
3212a
3210a
3212e
3210f
3204
3202
3214a 3218a 3214b 3218b 3214c 3218c 3214d 3218d
3216a 3220a 3216b 3220b 3216c 3220c 3216d 3220d

FIG. 32

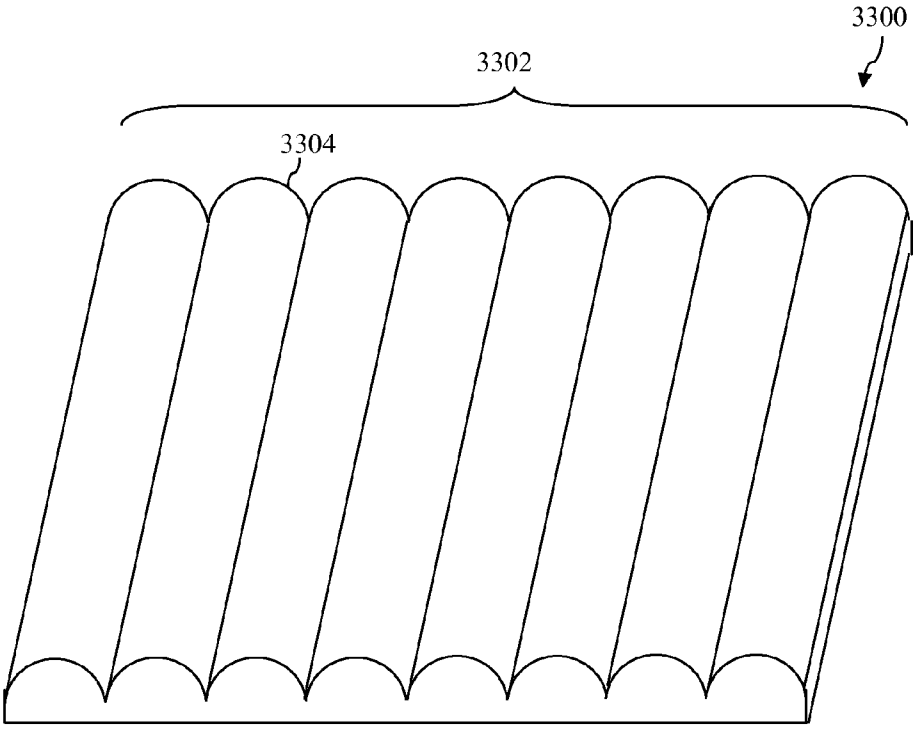



FIG. 33

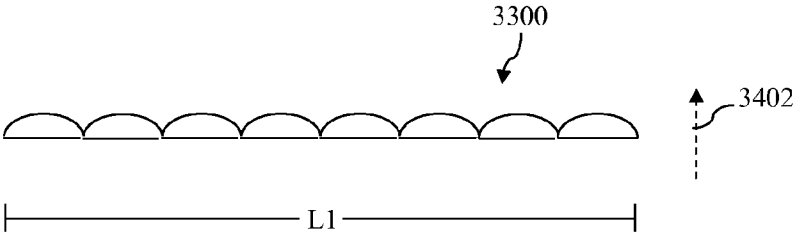



FIG. 34

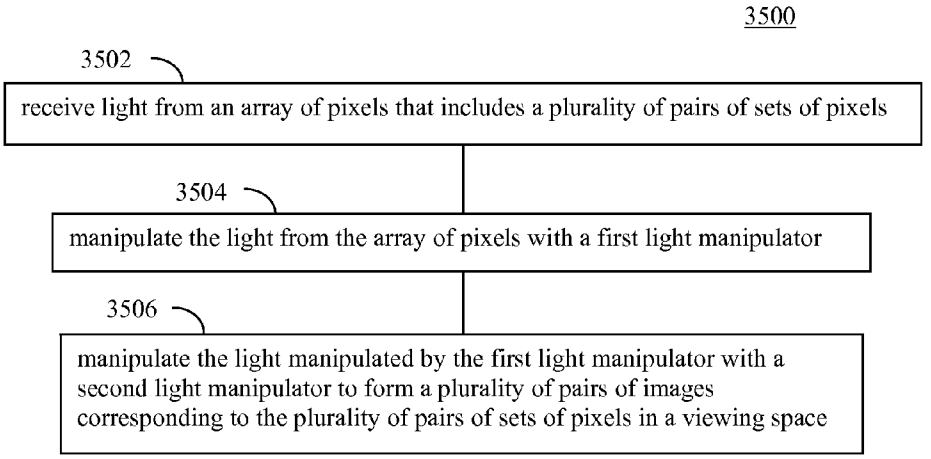

3500
3502
receive light from an array of pixels that includes a plurality of pairs of sets of pixels
3504
manipulate the light from the array of pixels with a first light manipulator
3506
manipulate the light manipulated by the first light manipulator with a second light manipulator to form a plurality of pairs of images corresponding to the plurality of pairs of sets of pixels in a viewing space

FIG. 35

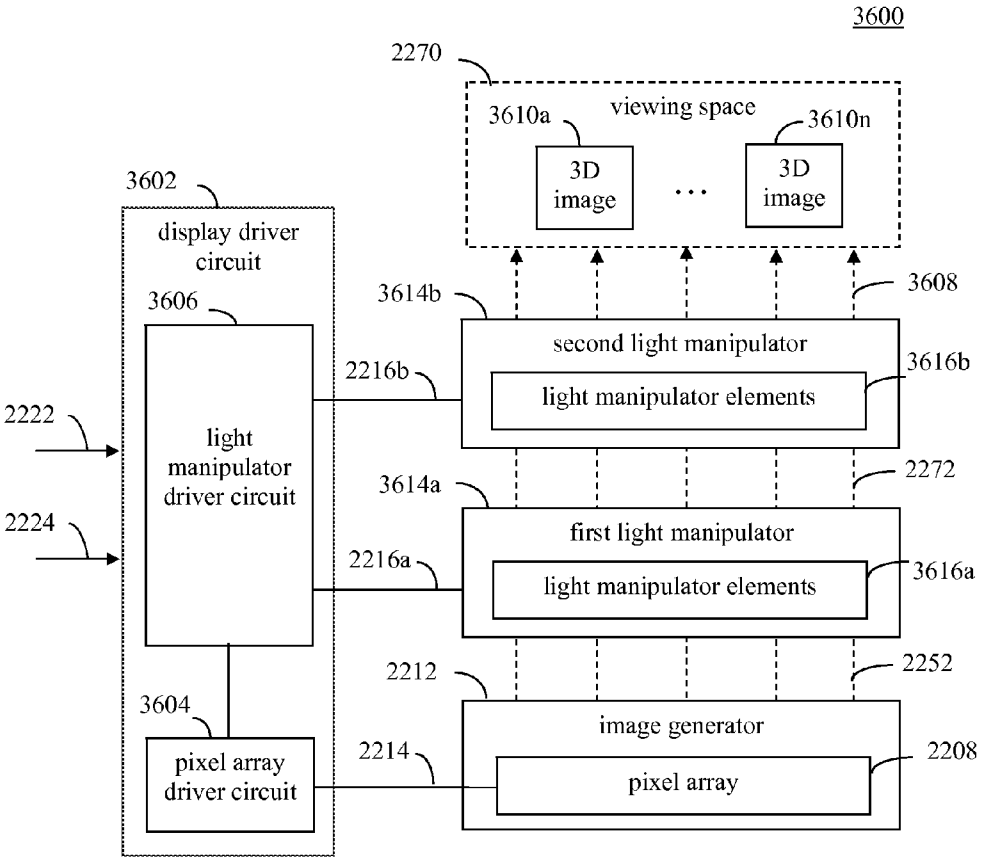

3600
2270
viewing space
3610a
3610n
3D image
3D image
3602
display driver circuit
3606
light manipulator driver circuit
3614b
second light manipulator
light manipulator elements
3608
2216b
3616b
2222
2224
3614a
first light manipulator
light manipulator elements
2272
2216a
3616a
2212
image generator
pixel array
2252
2208
3604
pixel array driver circuit
2214

FIG. 36

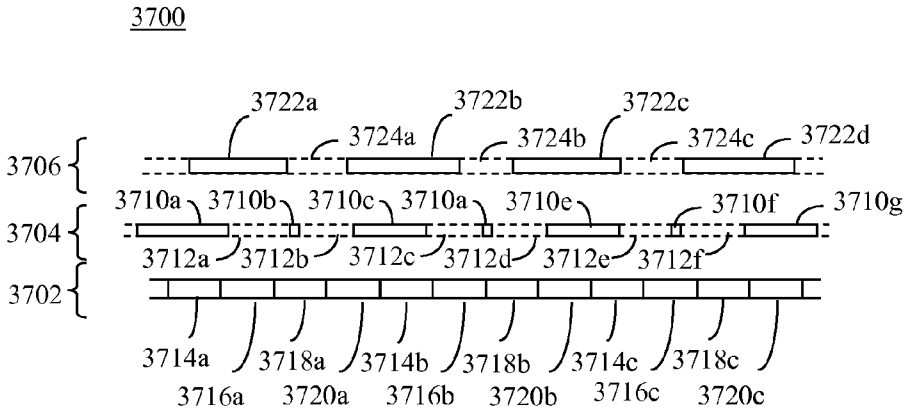

3700
3722a
3722b
3722c
3724a
3724b
3724c
3722d
3706
3710a
3710b
3710c
3710a
3710e
3710f
3710g
3704
3712a
3712b
3712c
3712d
3712e
3712f
3702
3714a
3718a
3714b
3718b
3714c
3718c
3716a
3720a
3716b
3720b
3716c
3720c

FIG. 37

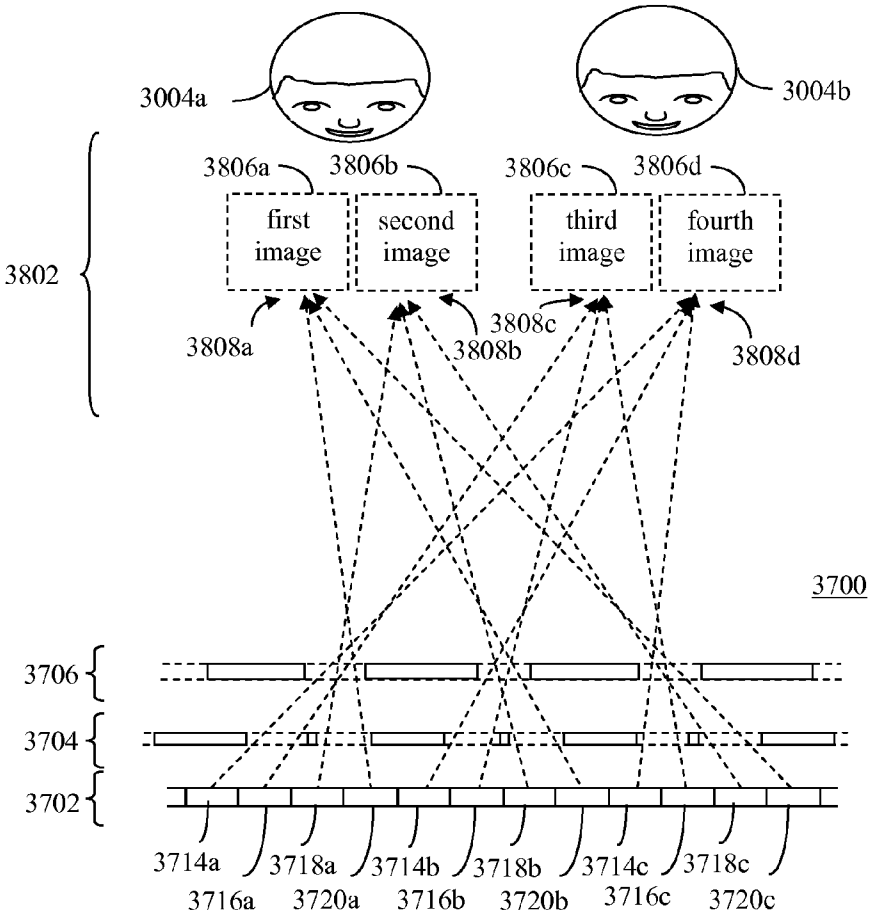

3004a
3004b
3806a
3806b
3806c
3806d
first image
second image
third image
fourth image
3802
3808a
3808b
3808c
3808d
3700
3706
3704
3702
3714a
3718a
3714b
3718b
3714c
3718c
3716a
3720a
3716b
3720b
3716c
3720c

FIG. 38

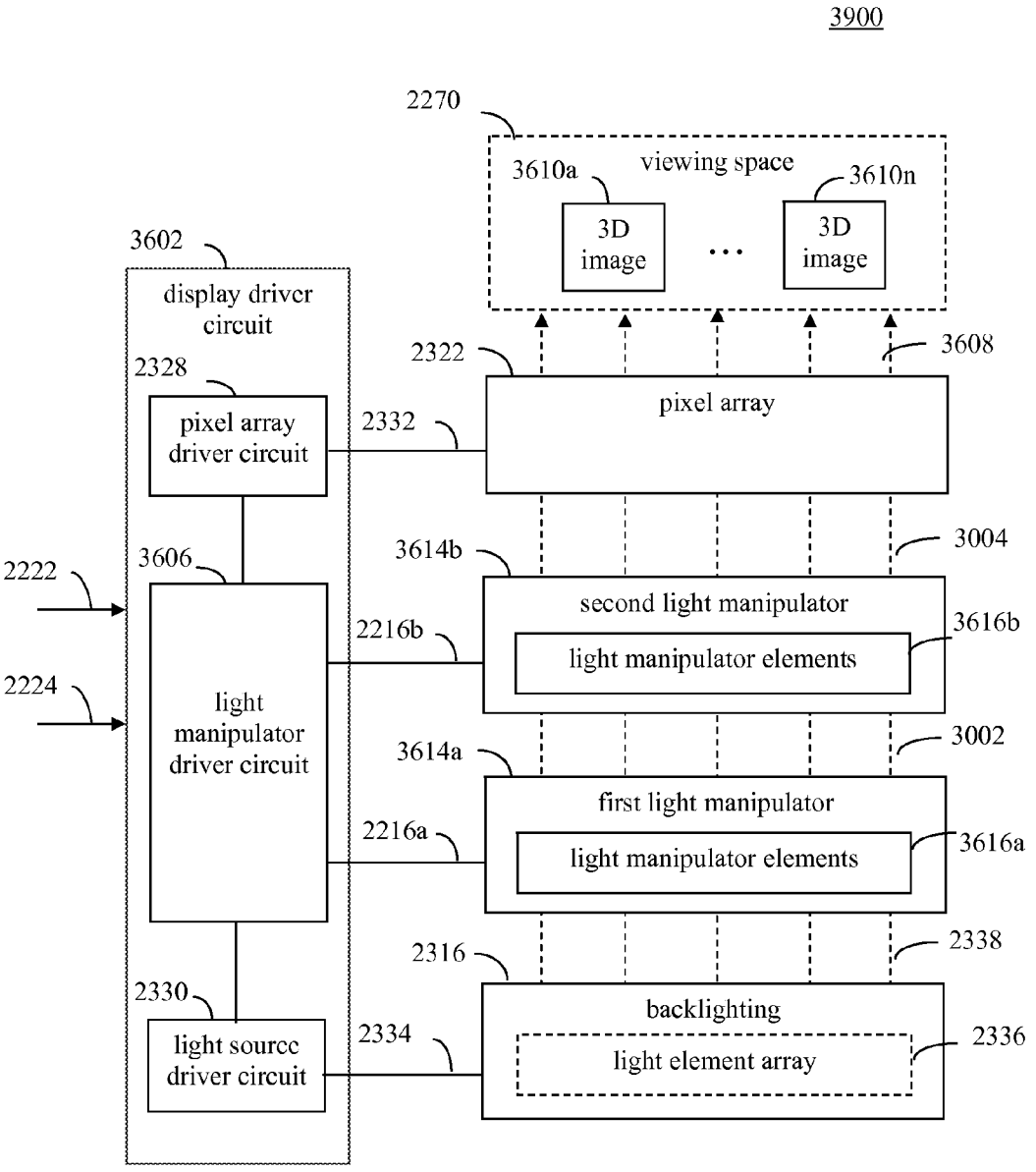

3900
2270
viewing space
3610a
3610n
3D image
3D image
3602
display driver circuit
2328
pixel array driver circuit
2332
2322
pixel array
3608
3004
3614b
second light manipulator
light manipulator elements
3616b
2216b
2222
2224
3606
light manipulator driver circuit
3614a
first light manipulator
light manipulator elements
3616a
2216a
3002
2316
backlighting
light element array
2336
2338
2330
light source driver circuit
2334

FIG. 39

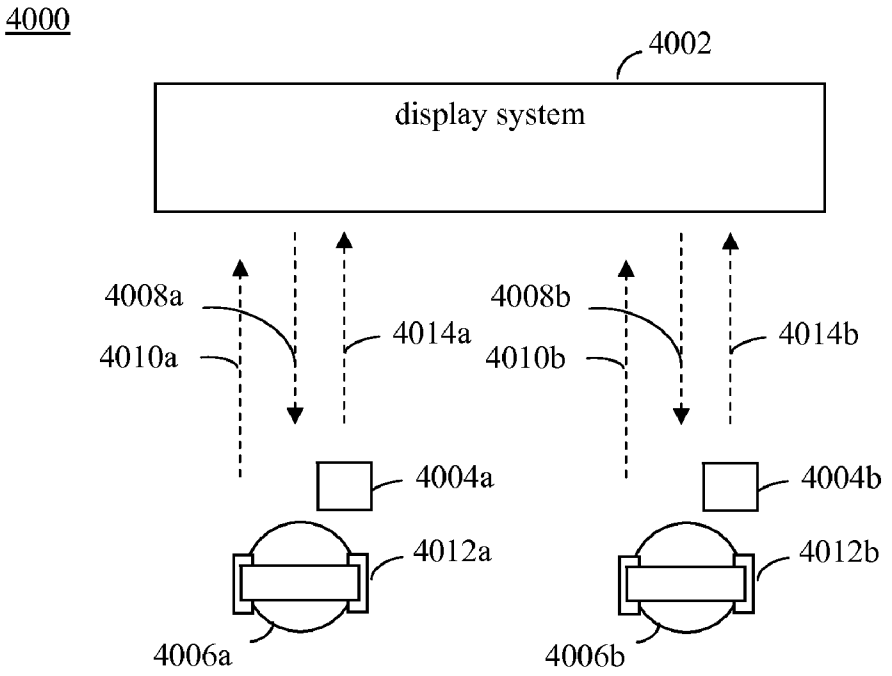

4000
4002
display system
4008a
4010a
4014a
4008b
4010b
4014b
4004a
4004b
4012a
4012b
4006a
4006b

FIG. 40

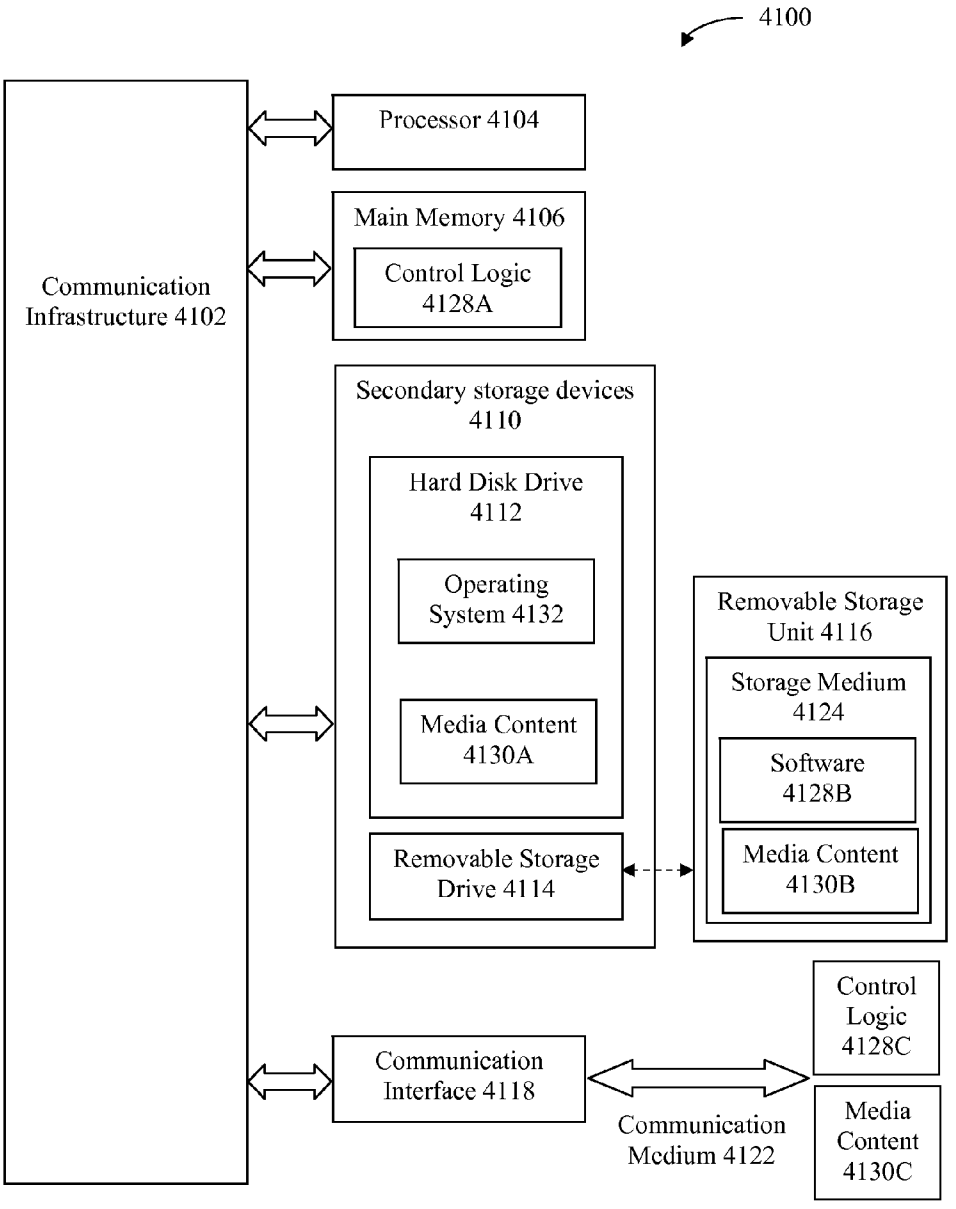

4100
Communication Infrastructure 4102
Processor 4104
Main Memory 4106
Control Logic 4128A
Secondary storage devices 4110
Hard Disk Drive 4112
Operating System 4132
Media Content 4130A
Removable Storage Drive 4114
Removable Storage Unit 4116
Storage Medium 4124
Software 4128B
Media Content 4130B
Communication Interface 4118
Communication Medium 4122
Control Logic 4128C
Media Content 4130C

FIG. 41

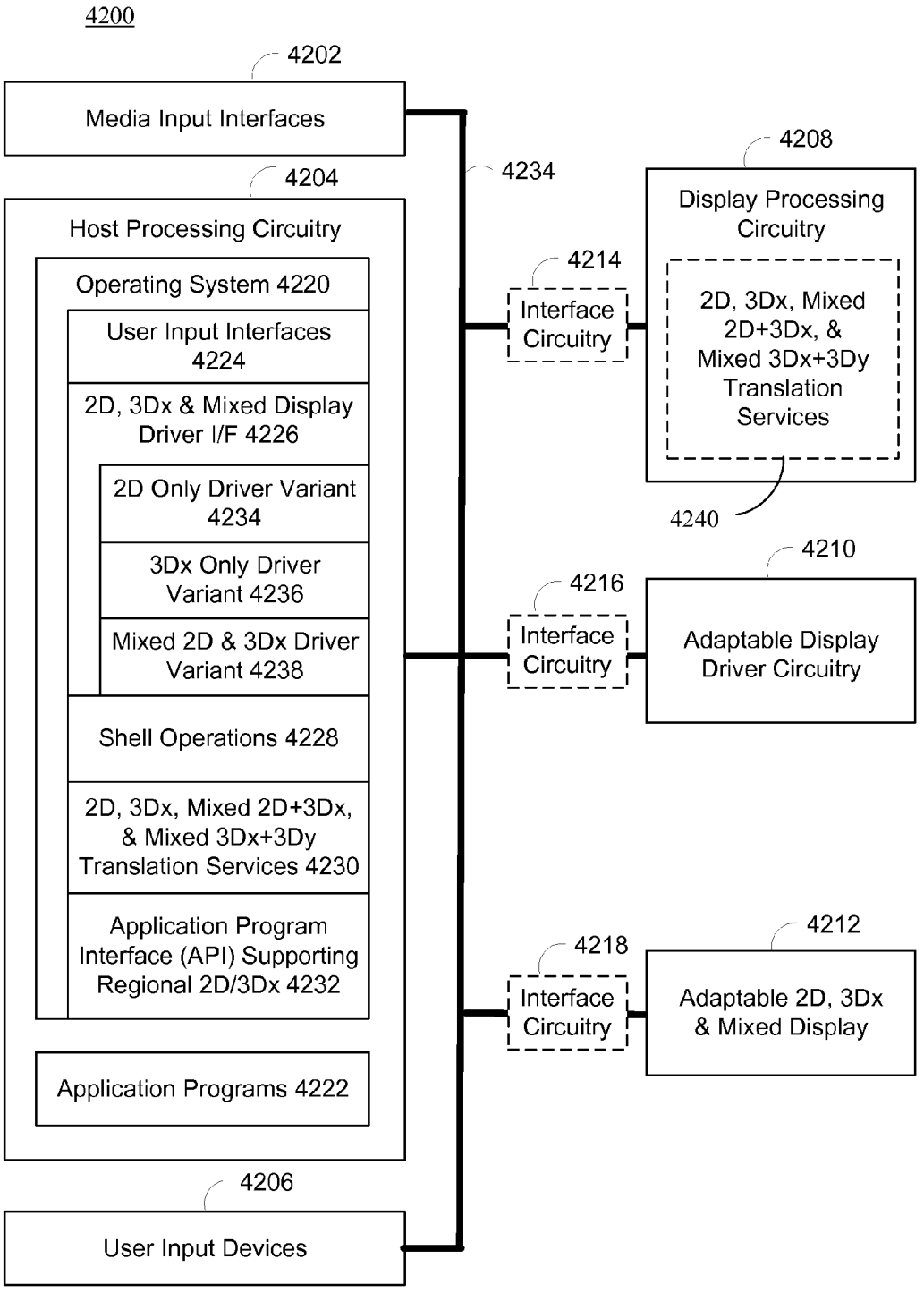

4200
4202
Media Input Interfaces
4204
Host Processing Circuitry
Operating System 4220
User Input Interfaces 4224
2D, 3Dx & Mixed Display Driver I/F 4226
2D Only Driver Variant 4234
3Dx Only Driver Variant 4236
Mixed 2D & 3Dx Driver Variant 4238
Shell Operations 4228
2D, 3Dx, Mixed 2D+3Dx, & Mixed 3Dx+3Dy Translation Services 4230
Application Program Interface (API) Supporting Regional 2D/3Dx 4232
Application Programs 4222
4206
User Input Devices
4234
4208
Display Processing Circuitry
4214
Interface Circuitry
2D, 3Dx, Mixed 2D+3Dx, & Mixed 3Dx+3Dy Translation Services
4240
4210
4216
Interface Circuitry
Adaptable Display Driver Circuitry
4212
4218
Interface Circuitry
Adaptable 2D, 3Dx & Mixed Display

FIG. 42

# OPERATING SYSTEM SUPPORTING MIXED 2D, STEREOSCOPIC 3D AND MULTI-VIEW 3D DISPLAYS

## CROSS REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims the benefit of U.S. Provisional Application No. 61/291,818, filed on Dec. 31, 2009, which is incorporated by reference herein in its entirety; and

**[0002]** This application claims the benefit of U.S. Provisional Application No. 61/303,119, filed on Feb. 10, 2010, which is incorporated by reference herein in its entirety.

**[0003]** This application is also related to the following U.S. Patent Applications, each of which also claims the benefit of U.S. Provisional Patent Application Nos. 61/291,818 and 61/303,119 and each of which is incorporated by reference herein:

**[0004]** U.S. patent application Ser. No. 12/845,409, titled "Display With Adaptable Parallax Barrier," filed Jul. 28, 2010;

**[0005]** U.S. patent application Ser. No. 12/845,440, titled "Adaptable Parallax Barrier Supporting Mixed 2D And Stereoscopic 3D Display Regions," filed Jul. 28, 2010;

**[0006]** U.S. patent application Ser. No. 12/845,461, titled "Display Supporting Multiple Simultaneous 3D Views," filed Jul. 28, 2010;

**[0007]** U.S. patent application Ser. No. 12/774,307, titled "Display with Elastic Light Manipulator," filed May 5, 2010;

**[0008]** U.S. patent application Ser. No. _____, titled "Backlighting Array Supporting Adaptable Parallax Barrier," filed on same date herewith;

**[0009]** U.S. patent application Ser. No. _____, titled "Internet Browser And Associated Content Definition Supporting Mixed Two And Three Dimensional Displays," filed on same date herewith;

**[0010]** U.S. patent application Ser. No. _____, titled "Application Programming Interface Supporting Mixed Two And Three Dimensional Displays," filed on same date herewith;

**[0011]** U.S. patent application Ser. No. _____, titled "Programming Architecture Supporting Mixed Two And Three Dimensional Displays," filed on same date herewith; and

**[0012]** U.S. patent application Ser. No. _____, titled "Integrated Backlighting, Sub-Pixel and Display Driver Circuitry Supporting Adaptive 2D, Stereoscopic 3D and Multi-View 3D Displays," filed on same date herewith.

## BACKGROUND OF THE INVENTION

**[0013]** 1. Field of the Invention

**[0014]** The present invention relates to operating systems associated with three-dimensional image displays.

**[0015]** 2. Background Art

**[0016]** Images may be generated for display in various forms. For instance, television (TV) is a widely used telecommunication medium for transmitting and displaying images in monochromatic ("black and white") or color form. Conventionally, images are provided in analog form and are displayed by display devices in two-dimensions. More recently, images are being provided in digital form for display in two-dimensions on display devices having improved resolution (e.g., "high definition" or "HD"). Even more recently, images capable of being displayed in three-dimensions are being generated.

**[0017]** Conventional displays may use a variety of techniques to achieve three-dimensional image viewing functionality. For example, various types of glasses have been developed that may be worn by users to view three-dimensional images displayed by a conventional display. Examples of such glasses include glasses that utilize color filters or polarized filters. In each case, the lenses of the glasses pass two-dimensional images of differing perspective to the user's left and right eyes. The images are combined in the visual center of the brain of the user to be perceived as a three-dimensional image. In another example, synchronized left eye, right eye LCD (liquid crystal display) shutter glasses may be used with conventional two-dimensional displays to create a three-dimensional viewing illusion. In still another example, LCD display glasses are being used to display three-dimensional images to a user. The lenses of the LCD display glasses include corresponding displays that provide images of differing perspective to the user's eyes, to be perceived by the user as three-dimensional.

**[0018]** Some displays are configured for viewing three-dimensional images without the user having to wear special glasses, such as by using techniques of autostereoscopy. For example, a display may include a parallax barrier that has a layer of material with a series of precision slits. The parallax barrier is placed proximal to a display so that a user's eyes each see a different set of pixels to create a sense of depth through parallax. Another type of display for viewing three-dimensional images is one that includes a lenticular lens. A lenticular lens includes an array of magnifying lenses configured so that when viewed from slightly different angles, different images are magnified. Displays are being developed that use lenticular lenses to enable autostereoscopic images to be generated.

**[0019]** As such, many types of display devices exist that are capable of displaying three-dimensional images, and further types are being developed. Different types of displays that enable three-dimensional image viewing may have different capabilities and attributes, including having different depth resolutions, being configured for three-dimensional image viewing only, being switchable between two-dimensional image viewing and three-dimensional image viewing, and further capabilities and attributes. Furthermore, different types of applications may be configured to provide and/or interact with the displays to provide either two-dimensional or three-dimensional image content. However, each application may not be directly compatible with each type of display device.

## BRIEF SUMMARY OF THE INVENTION

**[0020]** Methods, systems, and apparatuses are described for an operating system that interfaces users and applications with display devices that have three-dimensional image generating capability, substantially as shown in and/or described herein in connection with at least one of the figures, as set forth more completely in the claims.

## BRIEF DESCRIPTION OF THE DRAWINGS/FIGURES

**[0021]** The accompanying drawings, which are incorporated herein and form a part of the specification, illustrate the present invention and, together with the description, further

serve to explain the principles of the invention and to enable a person skilled in the pertinent art to make and use the invention.

**[0022]** FIG. **1** shows a block diagram of a system that includes an operating system that supports mixed 2D and 3D displays, according to an exemplary embodiment.

**[0023]** FIGS. **2** and **3** show block diagrams of systems that include operating systems that interface users, applications, and display devices and support mixed 2D and 3D displays, according to an exemplary embodiment.

**[0024]** FIG. **4**A shows a block diagram of a device that includes an operating system that supports mixed 2D and 3D displays, according to an exemplary embodiment.

**[0025]** FIG. **4**B shows a block diagram of system that includes an operating system that supports mixed 2D, stereoscopic 3D and multi-view 3D displays, according to an exemplary embodiment.

**[0026]** FIG. **5** shows a flowchart providing a process for interfacing an application with a display device through an operating system, according to an exemplary embodiment.

**[0027]** FIG. **6** shows a block diagram of an application interfaced with a display device by an operating system, according to an exemplary embodiment.

**[0028]** FIG. **7** shows a block diagram of a request, according to an exemplary embodiment.

**[0029]** FIG. **8** shows a flowchart providing a process for interfacing applications with a display device through an operating system, according to an exemplary embodiment.

**[0030]** FIG. **9** shows a block diagram of two applications interfaced with a display device by an operating system, according to an exemplary embodiment.

**[0031]** FIGS. **10**, **11**, **12**A, and **12**B show examples of a display screen displaying content in various screen regions, according to embodiments.

**[0032]** FIG. **13** shows a block diagram of a display driver, according to an exemplary embodiment.

**[0033]** FIG. **14** shows a flowchart providing a process for interfacing responses through an operating system, according to an exemplary embodiment.

**[0034]** FIG. **15** shows a block diagram of an application interfaced with a display device by an operating system, according to an exemplary embodiment.

**[0035]** FIG. **16** shows a flowchart providing a process for interfacing a user with a display device, according to an exemplary embodiment.

**[0036]** FIG. **17** shows a block diagram of a user interfaced with a display device by an operating system, according to an exemplary embodiment.

**[0037]** FIG. **18** shows a block diagram of an electronic device coupled to a display device, according to an exemplary embodiment.

**[0038]** FIG. **19** shows a block diagram of an operating system, according to an exemplary embodiment.

**[0039]** FIG. **20** shows a block diagram of a display device, according to an exemplary embodiment.

**[0040]** FIG. **21** shows a block diagram of a display device that is adaptable, according to an exemplary embodiment.

**[0041]** FIGS. **22** and **23** show block diagrams of examples of the display device of FIG. **21**, according to embodiments.

**[0042]** FIG. **24** shows a flowchart for generating three-dimensional images, according to an exemplary embodiment.

**[0043]** FIG. **25** shows a cross-sectional view of an example of a display system, according to an embodiment.

**[0044]** FIGS. **26** and **27** shows view of example parallax barriers with non-blocking slits, according to embodiments.

**[0045]** FIG. **28** shows a view of the barrier element array of FIG. **26** configured to enable the simultaneous display of two-dimensional and three-dimensional images of various sizes and shapes, according to an exemplary embodiment.

**[0046]** FIG. **29** shows a view of the parallax barrier of FIG. **26** with differently oriented non-blocking slits, according to an exemplary embodiment.

**[0047]** FIG. **30** shows a display system providing two two-dimensional images that are correspondingly viewable by a first viewer and a second viewer, according to an exemplary embodiment.

**[0048]** FIG. **31** shows a flowchart for generating multiple three-dimensional images, according to an exemplary embodiment.

**[0049]** FIG. **32** shows a cross-sectional view of an example of the display system of FIG. **22**, according to an embodiment.

**[0050]** FIGS. **33** and **34** show views of a lenticular lens, according to an exemplary embodiment.

**[0051]** FIG. **35** shows a flowchart for generating multiple three-dimensional images using multiple light manipulator layers, according to an exemplary embodiment.

**[0052]** FIG. **36** shows a block diagram of a display system, according to an exemplary embodiment.

**[0053]** FIGS. **37** and **38** show cross-sectional views of a display system, according to an exemplary embodiment.

**[0054]** FIG. **39** shows a block diagram of a display system, according to an exemplary embodiment.

**[0055]** FIG. **40** shows a block diagram of a display environment, according to an exemplary embodiment.

**[0056]** FIG. **41** shows a block diagram of an example electronic device, according to an embodiment.

**[0057]** FIG. **42** shows a block diagram of a display system that supports mixed 2D, stereoscopic 3D and multi-view 3D displays according to an exemplary embodiment.

**[0058]** The present invention will now be described with reference to the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements. Additionally, the left-most digit(s) of a reference number identifies the drawing in which the reference number first appears.

## DETAILED DESCRIPTION OF THE INVENTION

### I. Introduction

**[0059]** The present specification discloses one or more embodiments that incorporate the features of the invention. The disclosed embodiment(s) merely exemplify various aspects of the invention. The scope of the invention is not limited to the disclosed embodiment(s). The invention is defined by the claims appended hereto.

**[0060]** References in the specification to "one embodiment," "an embodiment," "an example embodiment," etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to effect such

feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

**[0061]** Furthermore, it should be understood that spatial descriptions (e.g., "above," "below," "up," "left," "right," "down," "top," "bottom," "vertical," "horizontal," ect.) used herein are for purposes of illustration only, and that practical implementations of the structures described herein can be spatially arranged in any orientation or manner.

## II. Exemplary Embodiments

**[0062]** Embodiments of the present invention relate to operating systems that interface users and applications with display devices that have three-dimensional image display capability. Numerous types of applications and display devices may be interfaced by the operating system. For example, the display devices may include one or more light manipulators, such as parallax barriers and/or lenticular lenses, to deliver 3D media content in the form of images or views to the eyes of the viewers. Other types may include display devices with 3D display pixel constructs that may or may not employ such light manipulators. When used, light manipulators may be fixed or dynamically modified to change the manner in which the views are delivered. For instance, embodiments enable light manipulators that are adaptable to accommodate a changing viewer sweet spot, switching between two-dimensional (2D), stereoscopic three-dimensional (3D), and multi-view 3D views, as well as the simultaneous display of 2D, stereoscopic 3D, and multi-view 3D content. With regard to parallax barriers, example features that may be dynamically modified include one or more of a number of slits in the parallax barriers, the dimensions of each slit, the spacing between the slits, and the orientation of the slits. Slits of the parallax barriers may also be turned on or off in relation to certain regions of the screen such that simultaneous mixed 2D, stereoscopic 3D, and multi-view 3D presentations can be accommodated. Similarly, a lenticular lens may be dynamically modified, such as by modifying a width of the lenticular lens, to modify delivered images.

**[0063]** The following subsections describe numerous exemplary embodiments of the present invention. For instance, the next subsection describes embodiments for operating systems, followed by a subsection that describes embodiments for interfacing applications with display devices, a subsection that describes embodiments for interfacing users with display devices, a subsection that describes operating system start up embodiments, a subsection that describes example display environments, and a subsection that describes example electronic devices.

**[0064]** It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made to the embodiments described herein without departing from the spirit and scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of exemplary embodiments described herein.

### A. Example Operating System Embodiments

**[0065]** In embodiments, operating systems that provide native support for the display of mixed content are provided. For example, in one embodiment, an operating system comprises a graphical user interface (GUI) in which video content, such as that produced by executing an application, can be displayed in a window or frame. The operating system enables one or more parameters to be associated with the window or frame, wherein the parameters can specify, for example, one or more of: a type of video content to be displayed within the window or frame (e.g., 2D, stereoscopic 3D, or a particular type of multi-view 3D), a desired orientation of the video content within the window or frame, a brightness/contrast to be associated with the window or frame, and/or a video resolution to be associated with the window or frame. The parameters to be associated with a window or frame may be specified programmatically or determined dynamically at run-time. The parameters may also be modified at run-time by a user through a user control interface provided by the operating system. The operating system is further configured to cause one or more function calls to be placed to a graphics API (application programming interface) or device driver so that a window is opened on the display and the video content is presented therein in a manner that is consistent with the associated parameters.

**[0066]** For instance, FIG. **1** shows a block diagram of a system **100**, according to an exemplary embodiment. As shown in FIG. **1**, system **100** includes one or more applications **104**, an operating system (OS) **106**, and hardware **108**. System **100** is a system where OS **106** interfaces together one or more users **102** and application(s) **104** with hardware **108**. System **100** may be implemented in a single device or across multiple devices.

**[0067]** OS **106** provides a platform on which programs may be executed. OS **106** may be implemented in software (e.g., computer programs and/or data) that runs on a device. OS **106** manages hardware **108**, provides common services, enables execution of application(s) **104**, and enables application(s) **104** to access hardware **108**. Application(s) **104** may call OS **106** and/or be interrupted by OS **106** for various reasons. OS **106** may include a user interface, such as a graphical user interface (GUI), which a user may interact with to access application(s) **104** and/or hardware **108**. In some cases, application(s) **104** may interact directly with hardware **108**. Hardware **108** may include one or more hardware components, such as one or more processors (e.g., a central processing unit) and/or memory devices (e.g., random access memory (RAM)), disk drives, printers, one or more display devices, a keyboard, a mouse, etc. Application(s) **104** may be implemented according to any suitable programming languages. Example description of implementations of programming languages for applications **104** and other applications described herein is provided in pending U.S. patent application Ser. No. _____, titled "Programming Architecture Supporting Mixed Two And Three Dimensional Displays," filed on same date herewith, which is incorporated by reference herein in its entirety, although application(s) **104** and further applications described herein are not limited to such implementations.

**[0068]** As shown in FIG. **1**, operating system **106** includes mixed 2D/3D supporting logic **110**. Mixed 2D/3D supporting logic **110** enables operating system **106** to support display of mixed 2D and 3D content, according to an exemplary embodiment. For example, logic **110** may enable operating system **106** to interface application(s) **104** that provide two-dimensional and/or three-dimensional content with display devices that are capable of separately displaying two-dimensional and three-dimensional content, display devices that are capable of simultaneously displaying two-dimensional and three-dimensional content, display devices that are capable of displaying different types of three-dimensional content, as

well as display devices that can adaptively change the display of two-dimensional and three-dimensional contents (e.g., by display screen region).

**[0069]** For instance, FIG. **2** shows a block diagram of a system **200**, which is an exemplary embodiment of system **100** of FIG. **1**. As shown in FIG. **2**, system **200** includes application(s) **104**, operating system (OS) **106**, and a display device **204**. As shown in FIG. **2**, operating system **106** includes mixed 2D/3D supporting logic **110**. Display device **204** is a display device associated with system **200** that is interfaced with application(s) **104** by OS **106**, and enables display of images associated with application(s) **104** to a user.

**[0070]** System **200** may be implemented in one or more devices. For example, in one embodiment, application(s) **104**, OS **106**, and display device **204** may be implemented in a common electronic device **206** accessed by a user, such as a mobile computing device (e.g., a handheld computer, a laptop computer, a notebook computer, a tablet computer (e.g., an Apple iPad™), a netbook, etc.), a mobile phone (e.g., a cell phone, a smart phone), a mobile email device, some types of televisions, etc. In another embodiment, as shown in FIG. **2**, OS **106** and application(s) **104** may be implemented together in an electronic device **202** that is separate from display device **204**. For instance, device **202** may be a home theater system receiver, a set-top box, a computer, a game console, or other such device, and display device **204** may be a display device that is coupled to device **202** in a wired or wireless fashion.

**[0071]** In embodiments, display device **204** may be one of a variety of display devices capable of displaying two-dimensional and/or three-dimensional images/content. For instance, FIG. **3** shows a block diagram of a system **300**, which is an exemplary embodiment of system **200** of FIG. **2**. As shown in FIG. **3**, system **300** includes application(s) **104**, operating system (OS) **106**, a first display device **304**, and a second display device **306**. As shown in FIG. **3**, operating system **106** includes mixed 2D/3D supporting logic **110**. First display device **304** is a display device that is only capable of displaying two-dimensional content, and second display device **306** is a display device that is capable of display two-dimensional content and three-dimensional content. In the example of FIG. **3**, via mixed 2D/3D supporting logic **110**, OS **106** is capable of interfacing application(s) **104** with first and second display devices **304** and **306**. As such, OS **106** is capable of interfacing two-dimensional and three-dimensional content with display devices. In embodiments, OS **106** may be capable of interfacing application(s) **104** with first and second display devices **304** and **306** one at a time. In another embodiment, OS **106** may be capable of interfacing application(s) **104** with first and second display devices **304** and **306** and/or other combinations and numbers of display devices simultaneously.

**[0072]** OS **106** may be implemented in various ways to interface a user and application(s) **104** with display devices that are capable of displaying two-dimensional content and/or three-dimensional content. For instance, FIG. **4**A shows a block diagram of an electronic device **412** that includes an operating system **400**, according to an exemplary embodiment. Device **412** may be any of the electronic devices mentioned herein as including an operating system (e.g., electronic devices **202** and **206** of FIG. **2**), or may be an alternative device. OS **400** is configured to interface users and applications with display devices that are capable of displaying two-dimensional content and/or three-dimensional content. In an embodiment, OS **400** may be a proprietary operating system. In another embodiment, OS **400** may be a commercially available operating system that is modified to enable users and applications to be interface with display devices capable of displaying two-dimensional content and/or three-dimensional content. For instance, operating systems such as Microsoft Windows®, Apple Mac OS® X, Google Android™, and Linux® may be modified according to embodiments.

**[0073]** As shown in FIG. **4**A, OS **400** includes a user input interface **402**, an API (application programming interface) **404**, a kernel **406**, and one or more display driver(s) **408**. User input interface **402** is configured to receive user input to enable a person to interact with device **412** and associated applications and hardware. For instance, user input interface **402** may provide a command-line interface that allows commands to be entered in the form of text, and/or may provide a graphical user interface (GUI) that provides a visual environment for a user to interact with device **412**. For instance, the GUI may generate graphical windows, buttons, menus, and/or icons displayed by a display device that may be interacted with by a user. In embodiments, user input interface **402** may be implemented in kernel **406**, or separately from kernel **406** (e.g., in user-space; as shown in FIG. **4**A).

**[0074]** API **404** is an interface implemented in software (e.g., computer program code or logic) that is configured to interface one or more applications (e.g., application(s) **104** of FIG. **1**) with OS **400**, and thereby interface the applications with a display device (e.g., one or both of display devices **304** and **306**) coupled to OS **400**. API **404** may be configured to enable applications to access various display functions, such as enabling regional definition for two-dimensional and/or three dimensional display screen areas, enabling movement of 2D/3D screen elements (e.g., windows or objects), and/or enabling further display functions by the applications. Furthermore, API **404** may be configured to perform graphics operations on graphics information received from applications for display. In embodiments, API **404** may be language dependent, such that API **404** may be accessed using a particular programming language, or may be language independent, such that API **404** can be accessed using multiple programming languages. API **404** may be a special purpose API, or may be a commercially available API, such as Microsoft DirectX® (e.g., Direct3D®), OpenGL®, or other 3D graphics API, which may be modified according to embodiments. Further description of implementations of API **404** and other API implementations described herein is provided in pending U.S. patent application Ser. No. _____, titled "Application Programming Interface Supporting Mixed Two And Three Dimensional Displays," filed on same date herewith, which is incorporated by reference herein in its entirety.

**[0075]** Kernel **406** is a central component of OS **400** that is configured to bridge applications and hardware. Kernel **406** may manage resources of device **412**, and enable applications to run and to use the resources. For instance, kernel **406** may allocate running applications to one or more processors of device **412**, may allocate memory to the applications, and may allocate requests from applications to perform I/O (input/output) operations with regard to hardware resources associated with device **412**, such as a keyboard, mouse, disk drives, printers, and displays. For example, as shown in FIG. **4**A, kernel **406** includes a display driver interface **410**. As described in further detail below, display driver interface **410** enables applications that interface with OS **400** via API **404** to

provide and control two- and/or three-dimensional content displayed at a display device associated with device **412**. For instance, display driver interface **410** may include mixed 2D/3D supporting logic **110** of FIG. **3**. To display an image on a screen of a display device, an application may provide a request to kernel **406**, which is handled by display driver interface **410**. Display driver interface **410** forwards the request to a display driver, which may handle generating plotting information for displaying the image at the display device.

**[0076]** Display driver(s) **408** are one or more display drivers that may be included in operating system **400**. A display driver **408** may be implemented in software, and enables applications (e.g., higher-level application code) to interact with a display device. Each display driver of display driver(s) **408** is typically display device-specific, although some display drivers may be capable of driving multiple types of display devices. Due to the presence of display driver(s) **408**, programmers can write and input higher-level application code to API **404** independently of the specific display device associated with device **412**, enabling the application code and display device to interface in a standard way. Each type of display device typically is controlled by its own display device-specific commands In contrast, most applications communicate with display devices according to high-level device-generic commands. A display driver **408** accepts the generic high-level commands (via API **404** and display driver interface **410**), and breaks them into a series of low-level display device-specific commands, as used by the particular display device. In an embodiment, a display driver **408** may be configured to filter out one or more parameters received with a command that is/are incompatible with the display device screen coupled to device **412**.

**[0077]** As such, using a display driver **408**, multiple applications that communicate using standard high-level commands can access a particular display device through OS **400**. Furthermore, OS **400** may include multiple display drivers **408** to enable multiple applications to communicate with multiple corresponding display devices.

**[0078]** As described above, OS **400** of FIG. **4**A is configured to interface users and applications with display devices that are capable of displaying two-dimensional content and/or three-dimensional content. OS **400** may be configured in various ways to perform its functions, and various embodiments for OS **400** are described herein. For instance, FIG. **4**B shows a block diagram of a display system **450** similar to display system **300** of FIG. **3**, according to an embodiment. As shown in FIG. **4**B, display system **450** includes an embodiment of OS **400** that is configured to interface users and applications with display devices that are capable of displaying two-dimensional content and/or three-dimensional content. The embodiment of OS **400** shown in FIG. **4**B is provided for purposes of illustration, and is not intended to be limiting. In further embodiments, OS **400** may include fewer, additional, and/or alternative features than shown in FIG. **4**B.

**[0079]** Display system **450** is an example of a display system that is capable of displaying mixed 2D and 3D content (e.g., via mixed 2D/3D supporting logic **110**). As shown in FIG. **4**B, system **450** includes operating system **400**, first-third application programs **414**, first-third display circuitry **416***a*-**416***c*, a 2D display **418***a*, a 3D display with 2D mode **418***b*, and a regionally configurable 2D/3Dx display **418***c*. Operating system **400** includes user input interfaces **420**, a 2D, 3Dx & mixed display driver interface **422**, shell operations **424**, 2D, 3Dx, mixed 2D and 3Dx, & mixed 3Dx and 3Dy translation services **426**, and an API supporting regional 2D/3Dx **428**. 2D, 3Dx and mixed display driver interface **422** includes 2D only driver variant **434**, 3Dx only driver variant **436**, and mixed 2D and 3Ds driver variant **438**. First application program **414***a* includes processed and/or generated content plus setup and control for multiple regions 2D/3Dx **432***a*. Second application program **414***b* includes internally processed single region 2D/3Dx content plus setup and control **432***b*. Third application program **414***c* includes internally generated signal region 2D/3Dx content plus setup and control **432***c*. First-third display circuitry **416***a*-**416***c* each include a corresponding one of translation services **430***a*-**430***c*. The features of system **450** are described as follows.

**[0080]** 2D display **418***a*, 3D display with 2D mode **418***b*, and regionally configurable 2D/3Dx display **418***c* are example types of display devices that may be interfaced with applications by OS **400**. One or more of displays **418***a*-**418***c* may be separately coupled to OS **400** (via display circuitry **416***a*-**416***c*) or simultaneously coupled to OS **400**. 2D display **418***a* is an example of 2D display device **304** of FIG. **3**, and is a display device that is only capable of displaying two-dimensional content. 3Dx display with 2D mode **418***b* is an example of 2D-3D display device **306** of FIG. **3**, and is a display device that is capable of displaying two-dimensional and three-dimensional content. For instance, 3Dx display with 2D mode **418***b* may be set in a 2D mode where 3Dx display with 2D mode **418***b* can display 2D content in full screen, but not 3D content, and may be set in a 3D mode where 3Dx display with 2D mode **418***b* can display 3D content in full screen, but not 2D content. Furthermore, 3Dx display with 2D mode **418***b* may be capable of displaying 3D content having multiple camera views—a number of "x" views—such as 3D-4, having four camera views, 3D-16, having sixteen camera views, etc. The additional camera views enable viewers to "view behind" displayed 3D content by moving their heads left-right, as further described elsewhere herein. Regionally configurable 2D/3Dx display **418***c* is an example of 2D-3D display device **306** of FIG. **3**, and is a display device that is capable of displaying two-dimensional and three-dimensional content simultaneously. For instance, regionally configurable 2D/3Dx display **418***c* may display 2D content on one or more regions of a display screen while simultaneously displaying 3D content on one or more other regions of the display screen. Furthermore, regionally configurable 2D/3Dx display **418***c* may be capable of displaying 3D content having multiple camera views.

**[0081]** First-third application programs **414***a*-**414***c* are examples of application(s) **104** of FIG. **4**A that may be interfaced with displays **418***a*-**418***c*. One or more of applications **414***a*-**414***c* may separately or simultaneously execute and interact with OS **400** to provide content for display by displays **418***a*-**418***c*. First application program **414***a*, which includes processed and/or generated content plus setup and control for multiple regions 2D/3Dx **432***a*, is capable of processing received 2D, 3D, and 3Dx content and/or generating 2D, 3D, and 3Dx content, and is capable of setting up and controlling multiple separate display screen regions that each display 2D, 3D, or 3Dx content. Second application program **414***b*, which includes internally processed single region 2D/3Dx content plus setup and control **432***b*, is capable of processing received 2D, 3D, and 3Dx content, and is capable of setting up and controlling a single display screen region

that displays 2D, 3D, or 3Dx content. Third application program **414***c*, which includes internally generated signal region 2D/3Dx content plus setup and control **432***c*, is capable of internally generating 2D, 3D, and 3Dx content, and is capable of setting up and controlling a single display screen region that displays 2D, 3D, or 3Dx content.

**[0082]** API supporting regional 2D/3Dx **428** is an example of API **404** of FIG. **4**A. API supporting regional 2D/3Dx **428** is configured to interface one or more applications (e.g., application **414**-**414***c*) with OS **400**, and thereby interface the applications with a display device (e.g., one or more of displays **418***a*-**418***c*) coupled to OS **400**. API supporting regional 2D/3Dx **428** is configured to enable applications to access various display functions, including enabling regional definition for 2D, 3D, and 3Dx content displayed by display screens and further display functions.

**[0083]** User input interfaces **420** are an example of user input interface **402** of FIG. **4**A. User input interfaces **420** are configured to receive user input to enable a person to interact with display system **450**, applications **414***a*-**414***c*, and content displayed by displays **418***a*-**418***c*.

**[0084]** 2D, 3Dx & mixed display driver interface **422** is an example of display driver interface **410** of FIG. **4**A, and 2D only driver variant **434**, 3Dx only driver variant **436**, and mixed 2D and 3Dx driver variant **438** are examples of display driver(s) **408** of FIG. **4**A. 2D, 3Dx & mixed display driver interface **422** enables applications **414***a*-**414***c* that interface with OS **400** via API **428** to provide and control two- and/or three-dimensional content displayed at a displays **418***a*-**418***c*. For instance, 2D, 3Dx & mixed display driver interface **422** may forward commands (e.g., from one or more of applications **414***a*-**414***c*) to 2D only driver variant **434** when 2D display **418***a* is present, enabling only 2D-related commands to be processed. 2D, 3Dx & mixed display driver interface **422** may forward commands to 3Dx only driver variant **436** when 3Dx display with 2D mode **418***b* is present, enabling 2D or 3Dx related commands to be processed. 2D, 3Dx & mixed display driver interface **422** may forward commands to mixed 2D and 3Dx driver variant **438** when regionally configurable 2D/3Dx display **418***c* is present, enabling regional 2D or 3Dx related commands to be processed.

**[0085]** Shell operations **424** may be present in OS **400** to control and/or enable user configuration of environmental properties, such as the 2D and/or 3D display configuration of an environmental background, of desktop icons, of displayed windows, etc. In embodiments, shell operations **424** may be implemented in hardware, software, firmware, or any combination thereof, including as a shell operations module. Examples of shell operations **424** are described elsewhere herein.

**[0086]** Mixed 2D and 3Dx, & mixed 3Dx and 3Dy translation services **426** may be present in OS **400** to provide for translation of received content (e.g., from applications **414***a*-**414***c*) from a first dimensionality to a second dimensionality. For instance, translation services **426** may be configured to translate received 3D content to 2D content, such as when an application provides 3D content, and 2D display **418***a* is the target display (e.g., the target display is not capable of displaying 3D content). In another example, translation services **426** may be configured to translate a first type of 3D content to a second type of 3D content, such as when an application provides regional 2D and/or 3D content, and 3Dx display with 2D mode is the target display (e.g., the target display is not capable of displaying content regionally), and/or to translate 3D content having a first number "x" of cameras (e.g., 3D-8 content) to 3D content having a second number "y" of cameras (e.g., 3D-4 content), if the target display does not support "x" camera views. Still further, translation services **426** may be configured to translate 2D content to 3D content, and/or may be able to perform other forms of content translations. Example embodiments for mixed 2D and 3Dx, & mixed 3Dx and 3Dy translation services **426** (e.g., translators) are described elsewhere herein.

**[0087]** Display circuitry **416***a*-**416***c* may have the form of hardware, software, firmware, or any combination thereof, such as having the form of a graphics card, circuitry etc. Display circuitry **416***a*-**416***c* may be present to interface OS **400** with displays **418***a*-**418***c*, respectively. Display circuitry **416***a*-**416***c* may receive content signals and control signals from OS **400**, and may be configured to generate drive signals to drive displays **418***a*-**418***c*, respectively. Examples of display circuitry (e.g., drive circuits) are described elsewhere herein.

**[0088]** As shown in FIG. **4**B, display circuitry **416***a*-**416***c* may each optionally include a corresponding one of translation services **430***a*-**430***c*. When present, translation services **430***a*-**430***c* may perform translations of received content in a similar manner as mixed 2D and 3Dx, & mixed 3Dx and 3Dy translation services **426**. For instance, translation services **430***a* may translate received 3D content to 2D content for display by 2D display **418***a*. Translation services **430***b* may translate received regionally configurable 2D and/or 3D content to non-regional 2D and/or 3D content for display by 3Dx display with 2D mode display **418***b*. Translation services **430***b* and **430***c* may each translate unsupported types of 3D content to supported types of 3D content for display by 3Dx display with 2D mode display **418***b* and regionally configurable 2D/3Dx display **418***c*, respectively. Translation services **430***a*-**430***c* may also be configured to perform additional and/or alternative forms of content translations, in embodiments.

**[0089]** The embodiments of display system **450** of FIG. **4**B, and of OS **400** shown in FIGS. **4**A and **4**B, are provided for purposes of illustration. In further embodiments, Display system **450** and OS **400** may include fewer, further, and/or alternative components, as would be known to persons skilled in the relevant art(s). Further embodiments regarding the features of display system **450** of FIG. **4**B and of OS **400** shown in FIGS. **4**A and **4**B are described in the following subsections.

### B. Exemplary Embodiments for Interfacing Applications and Display Devices

**[0090]** As described above, API **404** receives requests and content from applications for display devices associated with device **412**. FIG. **5** shows a flowchart **500** providing a process for interfacing an application with a display device through an operating system, according to an exemplary embodiment. Flowchart **500** may be performed by OS **400** shown in FIG. **4**A, for example. Flowchart **500** is described with respect to FIG. **6**, which shows a block diagram of an application **604** interfaced with a display device **606** by OS **400**, according to an exemplary embodiment. In the example of FIG. **6**, OS **400** includes user input interface **402**, API **404**, kernel **406**, and a display driver **618**. Display driver **618** is an example of one of display driver(s) **408** of FIG. **4**A. Device **412** of FIG. **4**A is not shown in FIG. **6** for ease of illustration, but it is noted that application **604** may be included in device **412**, and display

device **606** may be included in or may be external to device **412**. Further structural and operational embodiments will be apparent to persons skilled in the relevant art(s) based on the discussion regarding flowchart **500**. Flowchart **500** is described as follows.

**[0091]** Flowchart **500** begins with step **502**. In step **502**, a command directing display of content on a screen is received from an application. For example, as shown in FIG. **6**, a request **608** may be received by OS **400** from application **604**. Application **604** may be any type of application associated with the display of content, including a media player, a video game, a browser, etc. Request **608** may include a configuration command from application **604** directed to the display of content on a screen **620** of display device **606**. Request **608** may be directed to the display of two-dimensional or three-dimensional content, and may be directed to the display of content in any region of screen **620**, including a portion of screen **620** or the entirety of screen **620**. As shown in FIG. **6**, request **608** is received by API **404**. As such, request **608** is a command configured according to a convention defined by API **404** for receiving display configuration requests. As shown in FIG. **6**, API **404** passes request **608** to display driver interface **410** of kernel **406** as configuration command **610**. Furthermore, display driver interface **410** passes configuration command **610** to display driver **618** as configuration command **612**.

**[0092]** In step **504**, the command is responded to by sending a control signal that places the screen in a display mode corresponding to the content. For example, as shown in FIG. **6**, display driver **618** generates a control signal **614**. Control signal **614** is generated based on configuration command **612**, and is configured to place screen **620** of display device **606** in a display mode corresponding to content to be displayed by screen **620**. For instance, in an embodiment, display driver **618** is configured as a display driver specifically for display device **606**, or may be configured as a display driver for a plurality of types of display devices including display device **606**. Display device **606** receives control signal **614**, and screen **620** of display device **606** is configured according to control signal **614** to be enabled to display the content as desired. For example, in an embodiment, control signal **614** may be received by display driver circuits of display device **606**, and the display driver circuits may generate drive signals to configure display components of screen **620** according to control signal **614**.

**[0093]** Note that request **608** may have any suitable format, as defined by API **404**. For instance, FIG. **7** shows a block diagram of a request **700**, according to an exemplary embodiment. Request **700** is an example of request **608** of FIG. **6**. As shown in FIG. **7**, request **700** includes a command **702** and one or more parameters **704***a*-**704***n*. Request **700** may include any number of parameters **704**, as dictated by the particular command **702**. Request **700** may have various forms depending on the configuration action desired to be performed by application **604**.

**[0094]** For example, request **700** may be a request from application **604** to open a frame or window for display by screen **620** of display device **606**. In such an example, command **702** may be an "open frame" or "open window" command. Furthermore, one or more parameters **704** may be present to define attributes of the frame/window to be opened. For instance, one or more parameters **704** may be present to define a size of a region of screen **620** in which the frame or window is to be opened. For instance, parameters **704***a*-**704***d* may be row, column, width, and height parameters, respectively, where the row and column parameters (window position parameters) define coordinates of an upper left corner of the window to be opened, and the width and height parameters (window size parameters) define the width and height (e.g., in pixels or other measure) of the window to be opened. Furthermore, a parameter may be present to define whether the window to be opened is to display two-dimensional content or three-dimensional content. For instance, parameter **704***e* may be a 2D/3D indicator parameter that contains either a two-dimensional indicator or a three-dimensional indicator to define the window to be opened as displaying two-dimensional content or three-dimensional content, respectively.

**[0095]** The "open window" command may include further parameters **704**, such as a window resolution parameter, a window orientation parameter (e.g., whether image content is to be displayed vertically or rotated by 90 degrees or by other amount), a three-dimensional display type parameter, a subframe/full frame/child window parameter, a freeform window parameter (e.g., whether the window may have a non-rectangular shape), a three-dimensional content source indication parameter, etc. For example, in an embodiment, where a three-dimensional indicator is present in request **700**, a three-dimensional display type parameter may be present to define a number of image pairs to be provided to the window to be opened, corresponding to a number of three-dimensional views to be provided by the window (e.g., whether the window is not multiview or is multiview 4-3D, 16-3D, etc.). Furthermore, a three-dimensional display type parameter may be present to define a depth of three-dimensionality to be provided in the window to be opened. In another example, a parameter may be provided to indicate whether the window to be opened is to provide three-dimensional content and is to be adaptable based on factors such as bandwidth (e.g., increasing or decreasing a number of camera views that are displayed based on a data rate of incoming content), etc.

**[0096]** In a similar manner as the "open window" command, further commands may be defined by request **700**. In further examples, request **700** may be a request from application **604** to close a window displayed in screen **620**, to move a window displayed in screen **620**, to resize a window displayed in screen **620**, to rotate a window displayed in screen **620**, or other type of request. As such, command **702** may be a "close window" command, and one of parameters **704** may include a window handle identifying the window to be closed. In another example, command **702** may be "move window" command, and parameters **704** may include row and column parameters that define the new upper left corner of the window being moved. In another example, command **702** may be "resize window" command, and parameters **704** may include width and height parameters that define the new width and height of the window being resized. In still another example, command **702** may be "rotate window" command, and parameters **704** may include an indication (e.g., in degrees) of an amount by which the window is to be rotated.

**[0097]** In further embodiments, command **702** and parameters **704** may have other forms to define further functions, as would be apparent to persons skilled in the relevant art(s). For example, in embodiments, request **700** may be a request for information regarding an open window. For instance, command **702** may define a request for a window type (e.g., 2D or 3D), a window handle, a window position, an indication of the capabilities of the window and/or screen, and/or other window or screen characteristic. Another example command **702**

may define a request to OS **400** for capabilities of screen **620**/display device **606** so that applications may learn of window/screen capabilities prior to attempting to open and populate windows. Further commands **702** and parameters **704** may be defined as directed to frames, objects, and/or other display elements, having similar parameters as those defined above for windows, or having other parameters.

**[0098]** Referring back to FIG. **6**, after a window is opened in screen **620** according to request **608**, application **604** or other source may provide the corresponding two-dimensional or three-dimensional content to be displayed in the opened window. For instance, application **604** may generate and provide the content, or may receive and forward the content from another source, such as content received over a network, content received from a storage device associated with device **412** of FIG. **4**A (e.g., a hard disc drive, a DVD (digital video disc) drive, a memory stick, etc.). Application **604** may transmit the content, which is received by API **404**. API **404** may operationally perform some graphics processing on the content, and may provide the processed content to display driver **618** through display driver interface **410**, or directly to display driver **618**. Display driver **618** may perform further processing/formatting of the processed content, and may provide the content to display device **606** to be displayed by screen **620**.

**[0099]** As described above, multiple applications may simultaneously interface with a display device through OS **400**. For example, FIG. **8** shows a flowchart **800** providing a process for interfacing applications with a display device through an operating system, according to an exemplary embodiment. Flowchart **800** may be performed by OS **400** shown in FIG. **6**, for example. Flowchart **800** is described with respect to FIG. **9**, which shows a block diagram of first and second applications **604***a* and **604***b* interfaced with display device **606** by OS **400**, according to an exemplary embodiment. Note that although two applications **604** are shown in FIG. **9**, any number of applications **604** may be interfaced by OS **400** with a display device. Furthermore, such applications may be associated with any combination of two-dimensional and/or three dimensional content. Further structural and operational embodiments will be apparent to persons skilled in the relevant art(s) based on the discussion regarding flowchart **800**. Flowchart **800** is described as follows.

**[0100]** Flowchart **800** begins with step **802**. In step **802**, a first command is received from a first application directing display of two-dimensional content within a first region of the screen. For example, as shown in FIG. **9**, a first request **608***a* may be received by API **404** of OS **400** from first application **604***a*. First request **608***a* may include a configuration command from application **604***a* directed to the display of two-dimensional content on screen **620** of display device **606**. For instance, the command of request **608***a* may be an open window command or other command that enables or directs display of content in a particular first region of screen **620**, and may include a parameter that indicates that the displayed content is to be two-dimensional content.

**[0101]** In step **804**, the first command is responded to by sending a first control signal that places the screen in a two-dimensional mode within the first region. For instance, as shown in FIG. **9**, API **404** transmits a command **610***a* corresponding to request **608***a* that is received by display driver interface **410**, and display driver interface **410** passes command **610***a* to display driver **618** as command **612***a*. Display driver **618** generates a first control signal **614***a* that places screen **620** in a two-dimensional display mode within the first region of screen **620** indicated in first request **608***a*. For example, in an embodiment, first control signal **614***a* may be received by display driver circuits of display device **606**, and the display driver circuits may generate drive signals to configure display components of screen **620** with regard to the first screen region according to first control signal **614***a*.

**[0102]** In step **806**, a second command is received from a second application directing display of three-dimensional content within a second region of the screen. For example, as shown in FIG. **9**, a second request **608***b* may be received by API **404** of OS **400** from second application **604***b*. Second request **608***b* may include a configuration command from application **604***b* directed to the display of three-dimensional content on screen **620** of display device **606**. For instance, the command of request **608***b* may be an open window command or other command that enables or directs display of content in a particular second region of screen **620**, and may include a parameter that indicates that the displayed content is to be three-dimensional content.

**[0103]** In step **808**, the second command is responded to by sending a second control signal that places the screen in a three-dimensional mode within the second region. For instance, as shown in FIG. **9**, API **404** transmits a command **610***b* corresponding to request **608***b* that is received by display driver interface **410**, and display driver interface **410** passes command **610***b* to display driver **618** as command **612***b*. Display driver **618** generates a second control signal **614***b* that places screen **620** in a three-dimensional display mode within the second region of screen **620** indicated in second request **608***b*. For example, in an embodiment, second control signal **614***b* may be received by display driver circuits of display device **606**, and the display driver circuits may generate drive signals to configure display components of screen **620** with regard to the second screen region according to second control signal **614***b*.

**[0104]** As such, according to flowchart **800**, multiple applications may simultaneously direct the display of two-dimensional or three-dimensional content within corresponding regions of screen **620**. Furthermore, in embodiments, the display on screen **620** of different types of three-dimensional content (e.g., different resolutions, different numbers of image pairs, different stereoscopic depths, etc.) may be directed by multiple applications simultaneously. In embodiments, any number of different types of two-dimensional and three-dimensional content may be displayed in any number of regions of screen **620**.

**[0105]** For instance, FIGS. **10**, **11**, **12**A, and **12**B show examples of screen **620** displaying content in various screen regions, according to embodiments. FIG. **10** shows screen **620** including a first region **1002** and a second region **1004**. First region **1002** is configured for the display of two-dimensional content according to steps **802** and **804** of flowchart **800**, and second region **1004** is configured for the display of three-dimensional content according to steps **806** and **808** of flowchart **800**. As shown in FIG. **10**, first region **1002** has a size that is approximately the full display area of screen **620**, and second region **1004** has a smaller size, filling a rectangular space imposed on first region **1002**. For instance, in one embodiment provided for purposes of illustration, first region **1002** may be a two-dimensional desktop region displayed on a computer screen, and second region **1004** may be a window displaying three-dimensional content in the desktop region. In another embodiment, first region **1002** may correspond to

two-dimensional television content, while second region **1004** is a picture-in-picture region that displays three-dimensional television content overlaid on first region **1002**.

**[0106]** In another example, FIG. **11** shows screen **620** including a first region **1102** and a second region **1104**. First region **1102** is configured for the display of two-dimensional content according to steps **802** and **804** of flowchart **800**, and second region **1104** is configured for the display of three-dimensional content according to steps **806** and **808** of flowchart **800**. As shown in FIG. **11**, second region **1104** has a size that is approximately the full display area of screen **620**, and first region **1102** has a smaller size, filling a rectangular space imposed on second region **1104**. For instance, in one embodiment, second region **1104** may be a three-dimensional desktop region displayed on a computer screen, and first region **1102** may be a window displaying two-dimensional content in the desktop region. In another embodiment, second region **1104** may correspond to three-dimensional television content, while first region **1102** is a picture-in-picture region that displays two-dimensional television content overlaid on second region **1104**.

**[0107]** In another example, FIG. **12**A shows screen **620** including a first-ninth regions **1202-1218**. Any number of first-ninth regions **1202-1218** may be configured in a two-dimensional mode, and the remaining number of first-ninth regions **1202-1218** may be configured in a three-dimensional mode. For instance, second, fifth, sixth, seventh, and ninth regions **1204**, **1210**, **1212**, **1214** and **1218** may be configured for the display of two-dimensional content, and first, third, fourth, and eighth regions **1202**, **1206**, **1208**, and **1216** may be configured for the display of three-dimensional content. First region **1202** has a size that is approximately the full display area of screen **620**. Second-seventh regions **1204-1214** have smaller sizes, and are arranged in two columns on a left size of screen **620**. Eighth and ninth regions **1216** and **1218** have medium sizes, each filling a rectangular space imposed on first region **1202**. Eighth region **1216** overlaps with ninth region **1218**, blocking a view of a portion of ninth region **1218**. For instance, in one embodiment, first region **1202** may be a three-dimensional desktop region displayed on a computer screen, second-seventh regions **1204-1214** may be an arrangement of two-dimensional and three-dimensional icons (e.g., associated with applications) displayed on the desktop region, and eighth and ninth regions **1216** and **1218** may be windows displaying three-dimensional and two-dimensional content, respectively, in the desktop region.

**[0108]** FIG. **12**B depicts an example desktop **1222** displayed on screen **620** that includes a variety of areas in which respective instances of content may be presented in accordance with an embodiment. Desktop **1222** may be serviced by operating system (OS) objects, internet delivered media objects, boundaries, icons, etc., that are all subject to user setup and/or via a user's live interaction. The areas of desktop **1222** may include object perimeters, moving 3D objects, 2D or 3D icons or otherwise with 2D or 3D boundaries or interiors, etc. The exemplary areas of desktop **1222** shown in FIG. **12**B will now be described.

**[0109]** Desktop **1222** includes a background having a 2D sky area **1201** and a 3D grass region **1203** that appears to stretch far into the distance. Desktop **1222** further includes unselected icons **1213**, **1215**, and **1219** of random or arbitrary shapes which appear floating in mid-air in local 3D. Icons **1213** and **1219** may contain OS generated content, and icon **1215** may contain 3D content delivered live via an external server, for example. In accordance with this example, the 3D content in icon **1215** may be actively changing and/or moving around. Desktop **1222** further includes a selected icon **1217** which seems to be moving closer then farther away in a cycle, while the window **1225** that was opened and relates to selected icon **1217** has a boundary region **1211** that seems to actively change in synchrony therewith.

**[0110]** Desktop **1222** also includes an active, moving 2D or 3D object **1221** that has a non-rectangular boundary. Desktop **1222** further includes a pointer **1223** used to assist a viewer input and display control architecture **1229** that may be anything illustrated and discussed in the present application, and through which screen region configuration commands (command **1**, command **2**, etc.) can be accessed via, for example, a right click that opens a pop-up window **1225** or other type of window. Desktop **1222** also includes a rectangular window **1205** with 3D icons **1207** that may move and present local or delivered content, a 2D or 3D content screen **1209** (2D text or 3D movie for example originating remotely), and a 2D or 3D boundary **1211** as mentioned above related to the selected icon **1217**.

**[0111]** Viewer input and display control architecture **1229** represents one or more of any type of integrated and multiple-housing display and viewer control architectures. For instance, architecture **1229** may include one or more user input interfaces configured to receive user input. Examples of a user input interface include but are not limited to a remote control device, a traditional computer input device such as a keyboard or mouse, a touch screen, a gamepad or other type of gaming console input device, or one or more sensors including but not limited to video cameras, microphones and motion sensors. Such user input interface may generate an input signal that specifies settings for regionally adjustable characteristics of a screen assembly for presentation of the instances of content in the respective areas of desktop **1222**, for example, based on the user input.

**[0112]** The visual elements of desktop **1222**, including 2D and/or 3D aspects, sizes, movement, brightness, etc., of 2D sky area **1201**, 3D grass region **1203**, window **1205**, content screen **1209**, icons **1213**, **1215**, **1217**, and **1219**, object **1221**, pop-up window **1225**, etc., may be configured by applications providing commands through operating systems and/or OS commands generated by user interaction (e.g., with user input interfaces **420**), including commands for opening and tailoring windows, frame 3D/2D characteristics, depth, user interaction, supporting 2D/3D graphic objects, etc.

**[0113]** It is noted that the examples of FIGS. **10**, **11**, **12**A, and **12**B are provided for purposes of illustration, and are not intended to be limiting. In the examples of FIGS. **10**, **11**, **12**A, and **12**B, it is assumed that display device **606** supports the display of both two-dimensional and three-dimensional content. However, it is noted that not all types of display device **606** may support both two-dimensional content and three-dimensional content. Furthermore, not all types of display device **606** that support three-dimensional content may support all types of three-dimensional content. As such, in embodiments, OS **400** may be configured to translate unsupported types of content to supported types of content. Still further, screen regions may be rectangular in shape, as shown in FIGS. **10**, **11**, **12**A, and **12**B, or may have other shapes, including round or rounded, triangular or other polygon, or any other shape. For example, first-ninth regions **1202-1218** may each have the shape of a particular icon, and may be three-dimensional in shape, surrounded by a two-dimen-

sional background. A screen region may have any other shape, including the shape of an object, a displayed character (e.g., a person, an animal, an animated character, etc.), etc.

**[0114]** For example, in an embodiment, display drivers of OS **400** may be configured to translate types of content that are not supported by a display device associated with the display drivers to supported types of content. FIG. **13** shows a block diagram of display driver **618**, according to an exemplary embodiment. As shown in FIG. **13**, display driver **618** includes a first translator **1302** and a second translator **1304**. In embodiments, a display driver may include one or both of first and second translators **1302** and **1304**. First translator **1302** may be present in display driver **618** when display device **606** associated with display driver **618** does not support the display of three-dimensional content. Second translator **1302** may be present in display driver **618** when display device **606** associated with display driver **618** does not support the display of one or more types of three-dimensional content.

**[0115]** First translator **1302** is configured to translate received 3D data to 2D data for display by a display device. For example, as shown in FIG. **13**, display driver **618** receives configuration command **612**. Configuration command **612** may be a command to configure a region of screen **620** for display of three-dimensional content. However, display device **606** may not support the display of three-dimensional content. As such, display driver **618** may generate control signal **614** to configure the region of screen **620** indicated by command **612** for two-dimensional content instead of three-dimensional content. Furthermore, when subsequent three-dimensional data **1306** is received by display driver **618** for display in the region of screen **620**, first translator **1302** may translate three-dimensional data **1306** to two-dimensional data **1308**. Two-dimensional data **1308** is transmitted to display device **606** to enable the corresponding two-dimensional content to be displayed in the region of screen **620**.

**[0116]** Similarly, second translator **1304** is configured to translate received 3D data of a first 3D content type to 3D data of a second 3D content type for display by a display device. As shown in FIG. **13**, display driver **618** receives configuration command **612**. Configuration command **612** may be a command to configure a region of screen **620** for display of two-dimensional content of a first type. However, display device **606** may not support the display of three-dimensional content of the particular type. As such, display driver **618** may generate control signal **614** to configure the region of screen **620** indicated by command **612** for three-dimensional content of a second type instead of three-dimensional content of the first type. Furthermore, when subsequent first-type three-dimensional data **1310** is received by display driver **618** for display in the region of screen **620**, second translator **1304** may translate first-type three-dimensional data **1310** to second-type three-dimensional data **1312**. Second-type three-dimensional data **1312** is transmitted to display device **606** to enable the corresponding three-dimensional content to be displayed in the region of screen **620**.

**[0117]** First translator **1302** may be configured in various ways to translate received 3D data to 2D data. For instance, in an embodiment, three-dimensional data **1306** may be received as a stream of right image data and left image data. First translator **1302** may be configured to combine the right and left image data into two-dimensional image data that defines a stream of two-dimensional images that may be output as two-dimensional data **1308**. In another embodiment, first translator **1302** may be configured to select the right image data or the left image data to be output as two-dimensional data **1308**, while the other of the right image data or left image data is not used. In further embodiments, first translator **1302** may translate received 3D data to 2D data in other ways.

**[0118]** Second translator **1304** may be configured in various ways to translate 3D data of a first 3D content type to 3D data of a second 3D content type. For instance, second translator **1304** may translate a first 3D multiview type (e.g., 3D-16) to a second 3D multiview type (e.g., 3D-4) or to a single 3D view. In such an embodiment, second translator **1304** may not pass extra left-right image pairs from first-type three-dimensional data **1310** to second-type three-dimensional data **1312**. In further embodiments, second translator **1304** may translate 3D data in other ways.

**[0119]** Referring back to flowchart **500** of FIG. **5**, and flowchart **800** of FIG. **8**, OS **400** may pass responses from display devices back to applications in response to requests. For instance, FIG. **14** shows a flowchart **1400** providing a process for interfacing responses through an operating system, according to an exemplary embodiment. Flowchart **1400** may be performed by OS **400** shown in FIG. **6**, for example. Flowchart **1400** is described with respect to FIG. **15**, which shows a block diagram of application **604** interfaced with display device **606** by OS **400**, according to an exemplary embodiment. Further structural and operational embodiments will be apparent to persons skilled in the relevant art(s) based on the discussion regarding flowchart **1400**. Flowchart **1400** is described as follows.

**[0120]** Flowchart **1400** begins with step **1402**. In step **1402**, a response is received from the screen regarding the control signal. For example, as shown in FIG. **15**, display device **606** generates a response **1502**. Response **1502** contains information indicating a response to the previously received control signal (e.g., control signal **614** of FIG. **6**). For instance, response **1502** may include an indication (e.g., a logical "1" value" or "0" value) from the screen of whether a control signal was successful. Response **1502** is received by display driver **618**.

**[0121]** In step **1404**, the response is provided to the application. For example, display driver **618** may forward response **1502** to display driver interface **410** as response **1504**, and display driver interface **410** may forward response **1504** to API **404** as response **1506**. Alternatively, display driver **618** may forward response **1502** directly to API **404**. API **404** receives response **1506**, and provides response **1506** to application **604** as response **1508**.

**[0122]** Response **1508** may include any information suitable for a response by display device **606** to a control signal generated in response to a request **608**. For example, if request **608** included an "open window" command, response **1508** may indicate whether the window was successfully opened, and if so, may include a window handle for the opened window. Furthermore, response **1506** may indicate whether a "move window" command, a "close window" command, a "move window" command, a "resize window" command, a "rotate window" command, or other command included in a request **608** was successful.

### C. Example User Input Interface Embodiments

**[0123]** As described above, user input interface **402** receives user input to enable persons to interact with display devices associated with device **412**. For example, via user

input interface **402**, a user may be enabled to move displayed graphical objects (e.g., icons, windows, etc.), may be able to modify (e.g., rotate, resize, etc.) displayed graphical objects, to interact with displayed controls, etc. User input interface **402** may provide a command-line interface, a GUI, and/or other interface with which the user can interact. In embodiments, user input interface **402** may enable users to adjust three-dimensional characteristics of displayed three-dimensional content. For example, user input interface **402** may enable three-dimensionality of displayed content to be turned on or off (e.g., to toggle between two-dimensionality and three-dimensionality). User input interface **402** may enable a degree of three-dimensionality of displayed content to be modified (e.g., increased or decreased, such as by changing a depth of three-dimensionality, increasing or decreasing a number of supplied camera views, etc.), may enable three-dimensional objects to be rotated in three-dimensions, and/or may enable further types of adjustment to three-dimensional characteristics of displayed three-dimensional content. Furthermore, user input interface **402** may enable other characteristics of displayed content to be modified, such as modifying contrast, brightness, etc.

**[0124]** For instance, FIG. **16** shows a flowchart **1600** providing a process for interfacing a user with a display device, according to an exemplary embodiment. Flowchart **1600** is described with respect to FIG. **17**, which shows a block diagram where a user may be enabled to be interfaced with display device **606** by OS **400**, according to an exemplary embodiment. Further structural and operational embodiments will be apparent to persons skilled in the relevant art(s) based on the discussion regarding flowchart **1600**. Flowchart **1600** is described as follows.

**[0125]** Flowchart **1600** begins with step **1602**. In step **1602**, an input signal is received from a user input interface. For example, as shown in FIG. **17**, a user may interact with user input interface **402** to provide user input. User input interface **402** generates an input signal **1704** based on the user input, which is received by display driver interface **410**. Display driver interface **410** passes input signal **1704** to display driver **618** as input signal **1706**.

**[0126]** In embodiments, the user may interact with user input interface **402** in various ways, including using a mouse/pointing device to move a displayed pointer/cursor. The pointer may be used to "click and drag" objects to move them, to resize objects, to rotate objects, to select controls/settings, to open a pop-up menu, etc. In other embodiments, the user may interact with a keyboard, a thumb wheel or other wheel, a roller ball, a stick pointer, a touch sensitive display, any number of virtual interface elements (e.g., such as a keyboard or other user interface element displayed by screen **620**), a voice recognition system, and/or other user interface elements described elsewhere herein or otherwise known to provide user input. For instance, user input interface **402** may support a touch screen that is reactive to user finger touches to the screen to cause three-dimensional characteristics of displayed objects to be modified. For instance, particular motions of one or more figures against the screen may cause object resizing, 3D rotation, movement in 3D, etc. (e.g., touching two fingers to the screen, and dragging them together may be interpreted as "grabbing" a window and moving the window in 3D).

**[0127]** In step **1604**, a control signal is generated in response to the input signal, the control signal relating to a three-dimensional characteristic. For instance, as shown in FIG. **17**, display driver **618** generates a control signal **1708** based on input signal **1706**. In an embodiment, control signal **1708** relates to a three-dimensional characteristic. For instance, control signal **1708** may relate to selecting and/or modifying a three-dimensional characteristic indicated by a user interacting with user input interface **402**.

**[0128]** In step **1606**, the control signal is delivered to cause the adjustment of the three-dimensional characteristic of a three-dimensional content being displayed within the region of the screen. For example, as shown in FIG. **17**, display device **606** receives control signal **1708**. Control signal **1708** causes an adjustment of the three-dimensional characteristic of three-dimensional content displayed in a region of screen **620** (e.g., by causing a device driver circuit to generate corresponding drive signals).

**[0129]** For example, in step **1602** of flowchart **1600**, a user may interact with one of regions **1202-1218**, and/or with an object displayed within one of regions **1202-1218**. The user may resize a region and/or object that is displayed as three-dimensional, may rotate a region and/or object that is displayed as three-dimensional, may move a region and/or object that is displayed as three-dimensional in any of the three degrees (e.g., left-right, up-down, or forward-backward in FIG. **12**A) from a first screen region to a second screen region, may change a degree of three-dimensionality of a region and/or object that is displayed as three-dimensional (e.g., reducing or increasing a number of associated camera views), etc. In step **1604**, a control signal is generated to adjust the three-dimensional characteristic of the three-dimensional content being displayed, and in step **1606**, the control signal is delivered to the display screen to cause the adjustment of the three-dimensional characteristic to occur.

### D. Example Operating System Start Up Embodiments

**[0130]** In embodiments, users may have preferences with regard to a display environment upon powering on and/or logging into a device. Such preferences may include preferences with regard to display of three-dimensional content. For example, a user may desire for a television to power up in a two-dimensional or three-dimensional display mode, and if a three-dimensional display mode is desired, the user may have particular three-dimensional display preferences (e.g., a preferred degree of displayed three-dimensionality). In another example, with regard to a computer, a user may desire for the user's desktop environment to load with particular two-dimensional and/or three-dimensional display preferences. For instance, the user may desire for the desktop background to be displayed in two- or three-dimensions, may desire icons representing various executable applications to be displayed in two-dimensions and/or three-dimensions, etc. Furthermore, for each of the objects and/or regions displayed in three-dimensions, the user may have particular three-dimensional display preferences.

**[0131]** Embodiments enable display preferences to be set by users, and to be used to configure the display environments of users upon device boot up and/or user login. For instance, FIG. **18** shows a block diagram of an electronic device **1802** coupled to display device **606**, according to an exemplary embodiment. Device **1802** is an example of device **412** of FIG. **4**A. As shown in FIG. **18**, device **1802** includes a processor **1804**, a memory **1806**, and storage **1808**. Device **1802** may include additional features that are not shown in FIG. **18** for ease of illustration. Display device **606** may be included in

or may be external to device **1802**. Device **1802** may be any of the electronic devices mentioned herein as including an operating system, or may be an alternative device. The features of device **1802** shown in FIG. **18** are described as follows.

**[0132]** Memory **1806** may include one or more random access memory (RAM) devices, one or more read only memory (ROM) devices, and/or other memory devices. As shown in FIG. **18**, memory **1806** stores a boot loader **1810**. Boot loader **1810** may be a relatively short program that initiates a sequence of loading operations into memory **1806** when device **1802** is first powered on. For example, at power on of device **1802**, boot loader **1810** may be executed by processor **1804** to begin the loading sequence. Processor **1804** may include one or more processors and/or further processing logic. During the loading sequence defined by boot loader **1810**, operating system **1812** is caused to be loaded from storage **1808** into memory **1806**. Once loaded into memory **1806**, operating system **1812** may be executed by processor **1804**. Storage **1808** may include one or more non-volatile storage devices, such as a hard disk drive, a CDROM (compact disc ROM), a DVD (digital video disc), a flash memory card (e.g., an SD (secure digital) card), a USB (universal serial bus) flash drive, etc. Operating system **1812** is an example of operating system **400** described above.

**[0133]** Operating system **1812** may include a graphical user interface (GUI) generator (e.g., in user input interface **402**) used to render graphical user interfaces for users. For instance, FIG. **19** shows a block diagram of operating system **1812**, according to an exemplary embodiment. As shown in FIG. **19**, operating system **1812** includes a GUI generator **1902** and a boot up module **1904**. At power up, GUI generator **1902** may generate a GUI environment for a user according to boot up module **1904**. For example, when device **1802** is a computer, GUI generator **1902** may use boot up module **1904** to determine a desired desktop environment for the user. For instance, GUI generator **1902** may execute boot up module **1904** at power up. Boot up module **1904** may determine default GUI environment preferences (e.g., which may be stored in users preferences **1814** (FIG. **18**) as default device GUI environment preferences), and may determine the user's preferences for the GUI environment (e.g., a user's desktop environment), and GUI generator **1902** may generate the GUI environment accordingly.

**[0134]** For example, as shown in FIG. **18**, storage **1808** may store user preferences **1814** and user accounts **1816**. User preferences **1814** may include display preferences for one or more users, including preferences with regard to three-dimensional display characteristics of displayed objects and/or screen regions. User accounts **1816** may be present when users have associated login accounts for logging into device **1802**. In an embodiment, user accounts **1816** may be created for users, and during their creation, user preferences **1814** may be associated with user accounts **1816**. Furthermore, subsequent to creation of a user account, a user may be enabled to adjust their preferences stored in their user preferences associated with their user account. When device **1802** is powered up, boot up module **1904** may access default device preferences and user preferences for the user, and GUI generator **1902** may configure screen **606** according to the accessed default and/or user preferences **1814**. In an embodiment, boot up module **1904** may identify the user by a user account of user accounts **1816** into which the user may login, and the user account for the user may reference the preferences of the user in user preferences **1814**. User preferences **1814** for a user may indicate a desktop preference that indicates a preference for two-dimensional display or three-dimensional display of the user's desktop. User preferences **1814** may include further two-dimensional display and/or three-dimensional display preferences for users, such as display preferences for icons, windows, file folders/directory structures, regions, screen savers, desktop background, etc.

**[0135]** Thus, upon boot up, GUI generator **1902** may generate a GUI environment displayed in screen **620** for the user. GUI generator **1902** may execute boot up module **1904** to determine user preferences for the user (e.g., user preferences associated with a user account of the user). Furthermore, in an embodiment, boot up module **1904** may be configured to determine display capabilities of screen **620**. For instance, boot up module **1904** may perform a handshake with screen **620** on boot up to determine a three-dimensional display capability of screen **620**. GUI generator **1902** may then configure the GUI environment according to the determined capabilities of screen **620** and the preferences of the user. For instance, the user preferences of the user may include three-dimensional display characteristics that are beyond the determined capabilities of screen **620**. In such case, GUI generator **1902** may use determined default display characteristics (e.g., two-dimensional and/or three-dimensional) instead of the determined user preferences. Furthermore, in embodiments, three-dimensional characteristics of screen **620** may be selected based on other factors, including selecting/modifying an aspect of the display of the three-dimensional content based on change in a data rate of a received three-dimensional content data stream, and/or other factors.

### E. Example Display Device Screen Embodiments

**[0136]** Embodiments described herein for operating systems that support the display of two-dimensional and three-dimensional content may be implemented with respect to various types of display devices. For example, as described above, some display screens are configured for displaying two-dimensional content, although they may display two-dimensional images that may be combined to form three-dimensional images by special glasses worn by users. Some other types of display screens are capable of display two-dimensional content and three-dimensional content without the users having to wear special glasses using techniques of autostereoscopy.

**[0137]** As described above, display devices, such as display device **606**, may be implemented in various ways. For instance, display device **606** may be a television display (e.g., an LCD (liquid crystal display) television, a plasma television, etc.), a computer monitor, or any other type of display device. Display device **606** may include any suitable type or combination of light and image generating devices, including an LCD screen, a plasma screen, an LED (light emitting device) screen (e.g., an OLED (organic LED) screen), etc. Furthermore, display device **606** may include any suitable type of light filtering device, such as a parallax barrier (e.g., an LCD filter, a mechanical filter (e.g., that incorporates individually controllable shutters), etc.) and/or a lenticular lens, and may be configured in any manner, including as a thin-film device (e.g., formed of a stack of thin film layers), etc. Furthermore, display device **606** may include any suitable light emitting device as backlighting, including a panel of LEDs or other light emitting elements.

**[0138]** For instance, FIG. **20** shows a block diagram of a display device **2000**, according to an exemplary embodiment.

As shown in FIG. **20**, display device **2000** includes a screen **2002**. Display device **2000** is an example of display device **606** and screen **2002** is an example of screen **620** described above (e.g., with respect to FIG. **6**). Device **2000** receives one or more control signals **2006** (e.g., from OS **400**) that are configured to place screen **620** in a desired display mode (e.g., either a two-dimensional display mode or a three-dimensional display mode). As shown in FIG. **20**, screen **2004** includes a light manipulator **2004**. Light manipulator **2004** is configured to manipulate light that passes through light manipulator **2004** to enable three-dimensional images to be delivered to users in a viewing space. For instance, control signal(s) **2006** may be configured to activate or deactivate light manipulator **2004** to place screen **620** in a three-dimensional display mode or a two-dimensional display mode, respectively.

**[0139]** Examples of light manipulator **2004** include a parallax barrier and a lenticular lens. For instance, light manipulator **2004** may be a parallax barrier that has a layer of material with a series of precision slits. The parallax barrier is placed proximal to a light emitting pixel array so that a user's eyes each see a different set of pixels to create a sense of depth through parallax. In another embodiment, light manipulator **2004** may be a lenticular lens that includes an array of magnifying lenses configured so that when viewed from slightly different angles, different images are magnified. Such a lenticular lens may be used to deliver light from a different set of pixels of a pixel array to each of the user's eyes to create a sense of depth. Embodiments are applicable display devices that include such light manipulators, include other types of light manipulators, and that may include multiple light manipulators.

**[0140]** As shown in FIG. **20**, display device **2000** receives a content signal **2008** (e.g., from device **412** of FIG. **4**A, or other electronic device). Content signal **2008** includes two-dimensional or three-dimensional content for display by screen **2002**, depending on the particular display mode. In the embodiment of FIG. **20**, light manipulator **2004** is physically fixed—is not adaptable. As such, when present, light manipulator **2004** (e.g., a fixed parallax barrier or a fixed lenticular lens) always delivers three-dimensional images of a particular type to a particular region in a viewing space. As such, light manipulator **2004** is not adaptable to deliver other types of three-dimensional images and/or to deliver two and/or three-dimensional images to multiple different regions of a viewing space.

**[0141]** In contrast, FIG. **21** shows a block diagram of a display device **2100** that is adaptable, according to an exemplary embodiment. As shown in FIG. **21**, display device **2102** includes a screen **2102**. Display device **2100** is an example of display device **606** and screen **2102** is an example of screen **620** described above (e.g., with respect to FIG. **6**). Furthermore, as shown in FIG. **21**, screen **2102** includes an adaptable light manipulator **2104**. Adaptable light manipulator **2104** is configured to manipulate light that passes through adaptable light manipulator **2104** to enable three-dimensional images to be delivered to users in a viewing space. Furthermore, adaptable light manipulator **2104** is adaptable—is not physically fixed in configuration. As such, adaptable light manipulator **2104** is adaptable to deliver multiple different types of three-dimensional images and/or to deliver three-dimensional images to different/moving regions of a viewing space. Furthermore, in an embodiment, different regions of adaptable light manipulator **2104** may be adaptable such that multiple two-dimensional and/or three-dimensional images may be simultaneously delivered by screen **2102** to the viewing space.

**[0142]** Device **2100** receives one or more control signals **2106** (e.g., from OS **400**) that are configured to place screen **2102** in a desired display mode (e.g., either a two-dimensional display mode or a three-dimensional display mode), and/or to configure three-dimensional characteristics of any number and type as described above, such as configuring adaptable light manipulator **2104** to deliver different types of three-dimensional images, to deliver three-dimensional images to different/moving regions of a viewing space, and to deliver two-dimensional and/or three-dimensional images from any number of regions of screen **2102** to the viewing space.

**[0143]** As shown in FIG. **21** display device **2100** receives a content signal **2108** (e.g., from device **412** of FIG. **4**A, or other electronic device). Content signal **2108** includes two-dimensional and/or three-dimensional content for display by screen **2102**, depending on the particular display mode and on the number of regions of screen **2102** that are delivering different two- or three-dimensional views to a viewing space.

**[0144]** Content signals **2008** and **2108** may include video content according to any suitable format. For example, content signals **2008** and **2108** may include video content delivered over an HDMI (High-Definition Multimedia Interface) interface, over a coaxial cable, as composite video, as S-Video, a VGA (video graphics array) interface, etc.

**[0145]** Exemplary embodiments for display devices **2000** and **2100** of FIGS. **21** and **22** are described as follows for purposes of illustration.

1. Exemplary Embodiments Using Parallax Barriers

**[0146]** Display devices **2000** and **2100** may include parallax barriers as light manipulators **2004** and **2104**, respectively. For instance, FIG. **22** shows a block diagram of a display system **2200**, which is an example of display device **606**, according to an embodiment. As shown in FIG. **22**, system **2200** includes a display device driver circuit **2202**, an image generator **2212**, and parallax barrier **2220**. As shown in FIG. **22**, image generator **2212** includes a pixel array **2208**, and parallax barrier **2220** includes a barrier element array **2210**. Furthermore, as shown in FIG. **22**, display driver circuit **2202** includes a pixel array driver circuit **2204** and a barrier array driver circuit **2206**. These features of system **2200** are described as follows.

**[0147]** Pixel array **2208** includes a two-dimensional array of pixels (e.g., arranged in a grid or other distribution). Pixel array **2208** is a self-illuminating or light-generating pixel array such that the pixels of pixel array **2208** each emit light included in light **2252** emitted from image generator **2212**. Each pixel may be a separately addressable light source (e.g., a pixel of a plasma display, an LCD display, an LED display such as an OLED display, or of other type of display). Each pixel of pixel array **2208** may be individually controllable to vary color and intensity. In an embodiment, each pixel of pixel array **2208** may include a plurality of sub-pixels that correspond to separate color channels, such as a trio of red, green, and blue sub-pixels included in each pixel.

**[0148]** Parallax barrier **2220** is positioned proximate to a surface of pixel array **2208**. Barrier element array **2210** is a layer of parallax barrier **2220** that includes a plurality of barrier elements or blocking regions arranged in an array. Each barrier element of the array is configured to be selec-

tively opaque or transparent. Combinations of barrier elements may be configured to be selectively opaque or transparent to enable various effects. For example, in one embodiment, each barrier element may have a round, square, or rectangular shape, and barrier element array **2210** may have any number of rows of barrier elements that extend a vertical length of barrier element array **2210**. In another embodiment, each barrier element may have a "band" shape that extends a vertical length of barrier element array **2210**, such that barrier element array **2210** includes a single horizontal row of barrier elements. Each barrier element may include one or more of such bands, and different regions of barrier element array may include barrier elements that include different numbers of such bands.

**[0149]** One advantage of such a configuration where barrier elements extend a vertical length of barrier element array **2210** is that such barrier elements do not need to have spacing between them because there is no need for drive signal routing in such space. For instance, in a two-dimensional LCD array configuration, such as TFT (thin film transistor) display, a transistor-plus-capacitor circuit is typically placed onsite at the corner of a single pixel in the array, and drive signals for such transistors are routed between the LCD pixels (row-column control, for example). In a pixel configuration for a parallax barrier, local transistor control may not be necessary because barrier elements may not need to be changing as rapidly as display pixels (e.g., pixels of pixel array **2208**). For a single row of vertical bands of barrier elements, drive signals may be routed to the top and/or bottom of barrier elements. Because in such a configuration drive signal routing between rows is not needed, the vertical bands can be arranged side-by-side with little-to-no space in between. Thus, if the vertical bands are thin and oriented edge-to-edge, one band or multiple adjacent bands (e.g., five bands) may comprise a barrier element in a blocking state, followed by one band or multiple adjacent bands (e.g., two bands) that comprise a barrier element in a non-blocking state (a slit), and so on. In the example of five bands in a blocking state and two bands in a non-blocking state, the five bands may combine to offer a single black barrier element of approximately 2.5 times the width of a single transparent slit with no spaces therein.

**[0150]** It is noted that in some embodiments, barrier elements may be capable of being completely transparent or opaque, and in other embodiments, barrier elements may not be capable of being fully transparent or opaque. For instance, such barrier elements may be capable of being 95% transparent when considered to be "transparent" and may be capable of being 5% transparent when considered to be "opaque." "Transparent" and "opaque" as used herein are intended to encompass barrier elements being substantially transparent (e.g., greater than 75% transparent, including completely transparent) and substantially opaque (e.g., less than 25% transparent, including completely opaque), respectively.

**[0151]** Display driver circuit **2202** receives control signal **2222** and content signal **2224**. As described below, content signal **2224** includes two-dimensional and/or three-dimensional content for display. Control signal **2222** may be control signal **2006** of FIG. **20** (for a non-adaptable parallax barrier **2220**) or may be control signal **2106** of FIG. **21** (for an adaptable parallax barrier **2220**). Control signal **2222** may be received from a display driver of an operating system (e.g., may be control signal **614** received from display driver **618** of OS **400** in FIG. **6**). Display driver circuit **2202** is configured to generate drive signals based on control signal **2222** and content signal **2224** to enable display system **2200** to display two-dimensional and three-dimensional images to users **2218** in viewing space **2270**. For example, pixel array driver circuit **2204** is configured to generate a drive signal **2214** that is received by pixel array **2208** (e.g., based on content signal **2224** and/or control signal **2222**). Drive signal **2214** may include one or more drive signals used to cause pixels of pixel array **2208** to emit light **2252** of particular desired colors and/or intensity. Barrier array driver circuit **2206** is configured to generate a drive signal **2216** that is received by barrier element array **2210** (e.g., based on control signal **2222**). Drive signal **2216** may include one or more drive signals used to cause each of the barrier elements of barrier element array **2210** to be transparent or opaque. In this manner, barrier element array **2210** filters light **2252** to generate filtered light **2272** that includes one or more two-dimensional and/or three-dimensional images that may be viewed by users **2218** in viewing space **2270**. Example further description of implementations of the driver circuits described herein is provided in pending U.S. patent application Ser. No. _____, titled "Integrated Backlighting, Sub-Pixel and Display Driver Circuitry Supporting Adaptive 2D, Stereoscopic 3D and Multi-View 3D Displays," filed on same date herewith, which is incorporated by reference herein in its entirety, although the driver circuits described herein are not limited to such implementations.

**[0152]** For example, drive signal **2214** may control sets of pixels of pixel array **2208** to each emit light representative of a respective image, to provide a plurality of images. Drive signal **2216** may control barrier elements of barrier element array **2210** to filter the light received from pixel array **2208** according to the provided images such that one or more of the images are received by users **2218** in two-dimensional form. For instance, drive signal **2216** may select one or more sets of barrier elements of barrier element array **2210** to be transparent, to transmit one or more corresponding two-dimensional images or views to users **2218**. Furthermore, drive signal **2216** may control sections of barrier element array **2210** to include opaque and transparent barrier elements to filter the light received from pixel array **2208** so that one or more pairs of images or views provided by pixel array **2208** are each received by users **2218** as a corresponding three-dimensional image or view. For example, drive signal **2216** may select parallel strips of barrier elements of barrier element array **2210** to be transparent to form slits that enable three-dimensional images to be received by users **2218**.

**[0153]** In embodiments, drive signal **2216** may be generated by barrier array driver circuit **2206** to configure one or more characteristics of barrier element array **2210**. For example, drive signal **2216** may be generated to form any number of parallel strips of barrier elements of barrier element array **2210** to be transparent, to modify the number and/or spacing of parallel strips of barrier elements of barrier element array **2210** that are transparent, to select and/or modify a width and/or a length (in barrier elements) of one or more strips of barrier elements of barrier element array **2210** that are transparent or opaque, to select and/or modify an orientation of one or more strips of barrier elements of barrier element array **2210** that are transparent, to select one or more areas of barrier element array **2210** to include all transparent or all opaque barrier elements, etc.

**[0154]** FIG. **23** shows a block diagram of a display system **2300**, which is another example of display device **2100** of

FIG. **21**, according to an embodiment. As shown in FIG. **23**, system **2300** includes display device driver circuit **2202**, a pixel array **2322**, parallax barrier **2220**, and a backlighting **2316**. Parallax barrier **2220** includes barrier element array **2210** and backlighting **2316** includes a light element array **2336**. Furthermore, display driver circuit **2202** includes a pixel array driver circuit **2328**, barrier array driver circuit **2206**, and a light source driver circuit **2330**. These features of system **2300** are described as follows.

**[0155]** Backlighting **2316** is a backlight panel that emits light **2338**. Light element array **2336** (or "backlight array") of backlighting **2316** includes a two-dimensional array of light sources. Such light sources may be arranged, for example, in a rectangular grid. Each light source in light element array **2336** is individually addressable and controllable to select an amount of light emitted thereby. A single light source may comprise one or more light-emitting elements depending upon the implementation. In one embodiment, each light source in light element array **2336** comprises a single light-emitting diode (LED) although this example is not intended to be limiting. Further description of implementations of backlighting **2316** and other backlighting implementations described herein is provided in pending U.S. patent application Ser. No. _____, titled "Backlighting Array Supporting Adaptable Parallax Barrier," filed on same date herewith, which is incorporated by reference herein in its entirety.

**[0156]** Parallax barrier **2220** is positioned proximate to a surface of backlighting **2316** (e.g., a surface of the backlight panel). As described above, barrier element array **2210** is a layer of parallax barrier **2220** that includes a plurality of barrier elements or blocking regions arranged in an array. Each barrier element of the array is configured to be selectively opaque or transparent. Barrier element array **2210** filters light **2338** received from backlighting **2316** to generate filtered light **2340**. Filtered light **2340** is configured to enable a two-dimensional image or a three-dimensional image (e.g., formed by a pair of two-dimensional images in filtered light **2272**) to be formed based on images subsequently imposed on filtered light **2340** by pixel array **2322**.

**[0157]** Similarly to pixel array **2208** of FIG. **22**, pixel array **2322** of FIG. **23** includes a two-dimensional array of pixels (e.g., arranged in a grid or other distribution). However, pixel array **2322** is not self-illuminating, and instead is a light filter that imposes images (e.g., in the form of color, grayscale, etc.) on filtered light **2340** from parallax barrier **2220** to generate filtered light **2272** to include one or more images. Each pixel of pixel array **2322** may be a separately addressable filter (e.g., a pixel of a plasma display, an LCD display, an LED display, or of other type of display). Each pixel of pixel array **2322** may be individually controllable to vary the color imposed on the corresponding light passing through, and/or to vary the intensity of the passed light in filtered light **2272**. In an embodiment, each pixel of pixel array **2322** may include a plurality of sub-pixels that correspond to separate color channels, such as a trio of red, green, and blue sub-pixels included in each pixel.

**[0158]** Display driver circuit **2202** of FIG. **23** is configured to generate drive signals based on control signal **2222** and/or content signal **2224** to enable display system **2300** to display two-dimensional and three-dimensional images to users **2218** in viewing space **2270**. For example, light source driver circuit **2330** within display driver circuit **2202** controls the amount of light emitted by each light source in light element array **2336** by generating a drive signal **2334** that is received by light element array **2336** (based on content signal **2224** and/or control signal **2222**). Drive signal **2334** may include one or more drive signals used to control the amount of light emitted by each light source in light element array **2336** to generate light **2338**. As described above, barrier array driver circuit **2206** is configured to generate drive signal **2216** received by barrier element array **2210** (e.g., based on control signal **2222**). Drive signal **2216** may include one or more drive signals used to cause each of the barrier elements of barrier element array to be transparent or opaque, to filter light **2338** to generate filtered light **2340**. Pixel array driver circuit **2328** is configured to generate a drive signal **2332** that is received by pixel array **2322** (e.g., based on content signal **2224** and/or control signal **2222**). Drive signal **2332** may include one or more drive signals used to cause pixels of pixel array **2322** to impose desired images (e.g., colors, grayscale, etc.) on filtered light **2340** as it passes through pixel array **2322**. In this manner, pixel array **2322** generates filtered light **2272** that includes one or more two-dimensional and/or three-dimensional images that may be viewed by users **2218** in viewing space **2270**.

**[0159]** For example, drive signal **2334** may control sets of light sources of light element array **2336** to emit light **2338**. Drive signal **2216** may control barrier elements of barrier element array **2210** to filter light **2338** received from light element array **2336** to enable filtered light **2340** to enable two- and/or three-dimensionality. Drive signal **2332** may control sets of pixels of pixel array **2322** to filter filtered light **2340** according to respective images, to provide a plurality of images. For instance, drive signal **2216** may select one or more sets of the barrier elements of barrier element array **2210** to be transparent, to enable one or more corresponding two-dimensional images to be delivered to users **2218**. Furthermore, drive signal **2216** may control sections of barrier element array **2210** to include opaque and transparent barrier elements to filter the light received from light element array **2336** so that one or more pairs of images provided by pixel array **2322** are each enabled to be received by users **2218** as a corresponding three-dimensional image. For example, drive signal **2216** may select parallel strips of barrier elements of barrier element array **2210** to be transparent to form slits that enable three-dimensional images to be received by users **2218**.

**[0160]** FIG. **24** shows a flowchart **2400** for generating images that are delivered to users in a viewing space, according to an exemplary embodiment. Flowchart **2400** may be performed by system **2200** in FIG. **22** or system **2300** of FIG. **23**, for example. Flowchart **2400** is described with respect to FIG. **25**, which shows a cross-sectional view of a display system **2500**. Display system **2500** is an exemplary embodiment of system **2200** shown in FIG. **22**, and is shown for purposes of illustration. As shown in FIG. **25**, system **2500** includes a pixel array **2502** and a barrier element array **2504**. In another embodiment, system **2500** may further include backlighting in a configuration similar to display system **2300** of FIG. **23**. Further structural and operational embodiments will be apparent to persons skilled in the relevant art(s) based on the discussion regarding flowchart **2400**. Flowchart **2400** is described as follows.

**[0161]** Flowchart **2400** begins with step **2402**. In step **2402**, light is received at an array of barrier elements. For example, as shown in FIG. **22**, light **2252** is received at parallax barrier **2220** from pixel array **2208**. Each pixel of pixel array **2208** may generate light that is received at parallax barrier **2220**.

Depending on the particular display mode of parallax barrier **2220**, parallax barrier **2220** may filter light **2252** from pixel array **2208** to generate a two-dimensional image or a three-dimensional image viewable in viewing space **2270** by users **2218**. As described above with respect to FIG. **23**, alternatively, light **2338** may be received by parallax barrier **2220** from light element array **2336**.

**[0162]** In step **2404**, a first set of the barrier elements of the array of barrier elements is configured in the blocking state and a second set of the barrier elements of the array of barrier elements is configured in the non-blocking state to enable a viewer to be delivered a three-dimensional view. Three-dimensional image content may be provided for viewing in viewing space **2270**. In such case, referring to FIG. **22** or **23**, barrier array driver circuit **2206** may generate drive signal **2216** to configure barrier element array **2210** to include transparent strips of barrier elements to enable a three-dimensional view to be formed. For example, as shown in FIG. **25**, barrier element array **2504** includes a plurality of barrier elements that are each either transparent (in a non-blocking state) or opaque (in a blocking state). Barrier elements that are blocking are indicated as barrier elements **2510***a*-**2510***f*, and barrier elements that are non-blocking are indicated as barrier elements **2512***a*-**2512***e*. Further barrier elements may be included in barrier element array **2504** that are not visible in FIG. **25**. Each of barrier elements **2510***a*-**2510***f* and **2512***a*-**2512***e* may include one or more barrier elements. Barrier elements **2510** alternate with barrier elements **2512** in series in the order of barrier elements **2510***a*, **2512***a*, **2510***b*, **2512***b*, **2510***c*, **2512***c*, **2510***d*, **2512***d*, **2510***e*, **2512***e*, and **2510***f*. In this manner, blocking barrier elements **2510** are alternated with non-blocking barrier elements **2512** to form a plurality of parallel non-blocking or transparent slits in barrier element array **2504**.

**[0163]** For instance, FIG. **26** shows a view of a parallax barrier **2600** with transparent slits, according to an exemplary embodiment. Parallax barrier **2600** is an example of parallax barrier **2220** of FIGS. **22** and **23**. As shown in FIG. **26**, parallax barrier **2600** includes barrier element array **2602**, which includes a plurality of barrier elements **2604** arranged in a two-dimensional array. Furthermore, as shown in FIG. **26**, barrier element array **2602** includes a plurality of parallel strips of barrier elements **2604** that are selected to be non-blocking to form a plurality of parallel non-blocking strips (or "slits") **2606***a*-**2606***g*. As shown in FIG. **26**, parallel non-blocking strips **2606***a*-**2606***g* (non-blocking slits) are alternated with parallel blocking or blocking strips **2608***a*-**2608***g* of barrier elements **2604** that are selected to be blocking. In the example of FIG. **26**, non-blocking strips **2606***a*-**2606***g* and blocking strips **2608***a*-**2608***g* each have a width (along the x-dimension) of two barrier elements **2604**, and have lengths that extend along the entire y-dimension (twenty barrier elements **2604**) of barrier element array **2602**, although in other embodiments, may have alternative dimensions. Non-blocking strips **2606***a*-**2606***g* and blocking strips **2608***a*-**2608***g* form a parallax barrier configuration for parallax barrier **300**. The spacing (and number) of parallel non-blocking strips **2606** in barrier element array **2602** may be selectable by choosing any number and combination of particular strips of barrier elements **2604** in barrier element array **2602** to be non-blocking, to be alternated with blocking strips **2608**, as desired. For example, hundreds, thousands, or even larger numbers of non-blocking strips **2606** and blocking strips **2608** may be present in parallax barrier **300**.

**[0164]** FIG. **27** shows a parallax barrier **2700** that is another example of parallax barrier **2220** with parallel transparent slits, according to an embodiment. Similarly to parallax barrier **2600** of FIG. **26**, parallax barrier **2700** has includes a barrier element array **2712**, which includes a plurality of barrier elements **2714** arranged in a two-dimensional array (28 by 1 array). Barrier elements **2714** have widths (along the x-dimension) similar to the widths of barrier elements **2604** in FIG. **26**, but have lengths that extend along the entire vertical length (y-dimension) of barrier element array **2714**. As shown in FIG. **27**, barrier element array **2712** includes parallel non-blocking strips **2606***a*-**2606***g* alternated with parallel blocking strips **2608***a*-**2608***g*. In the example of FIG. **27**, parallel non-blocking strips **2606***a*-**2606***g* and parallel blocking strips **2608***a*-**2608***g* each have a width (along the x-dimension) of two barrier elements **2714**, and have lengths that extend along the entire y-dimension (one barrier element **314**) of barrier element array **2712**.

**[0165]** Referring back to FIG. **24**, in step **2406**, the light is filtered at the array of barrier elements to form the three-dimensional view in a viewing space. Barrier element array **2210** of parallax barrier **2220** is configured to filter light **2252** received from pixel array **2208** (FIG. **22**) or light **2338** received from light element array **2336** (FIG. **23**) according to whether barrier element array **2210** is transparent or non-blocking (e.g., in a two-dimensional mode) or includes parallel non-blocking strips (e.g., in a three-dimensional mode). If one or more regions of barrier element array **2210** are transparent, those regions of barrier element array **2210** function as "all pass" filters to substantially pass all of light **2252** as filtered light **2272** to deliver one or more corresponding two-dimensional images generated by pixel array **2208** to viewing space **2270**, to be viewable as a two-dimensional images in a similar fashion as a conventional display. If barrier element array **2210** includes one or more regions having parallel non-blocking strips (e.g., as shown for barrier element array **2602** in FIGS. **26** and **27**), those regions of barrier element array **2210** pass a portion of light **2252** as filtered light **2272** to deliver one or more corresponding three-dimensional images to viewing space **2270**.

**[0166]** For example, as shown in FIG. **25**, pixel array **2502** includes a plurality of pixels **2514***a*-**2514***d* and **2516***a*-**2516***d*. Pixels **2514** alternate with pixels **2516**, such that pixels **2514***a*-**2514***d* and **2516***a*-**2516***d* are arranged in series in the order of pixels **2514***a*, **2516***a*, **2514***b*, **2516***b*, **2514***c*, **2516***c*, **2514***d*, and **2516***d*. Further pixels may be included in pixel array **2502** that are not visible in FIG. **25**, including further pixels along the width dimension of pixel array **2502** (e.g., in the left-right directions) as well as pixels along a length dimension of pixel array **2502** (not visible in FIG. **25**). Each of pixels **2514***a*-**2514***d* and **2516***a*-**2516***d* generates light, which emanates from display surface **2524** of pixel array **2502** (e.g., generally upward in FIG. **25**) towards barrier element array **2504**. Some example indications of light emanating from pixels **2514***a*-**2514***d* and **2516***a*-**2516***d* are shown in FIG. **25** (as dotted lines), including light **2524***a* and light **2518***a* emanating from pixel **2514***a*, light **2524***b*, light **2518***b*, and light **2524***c* emanating from pixel **2514***b*, etc.

**[0167]** Furthermore, light emanating from pixel array **2502** is filtered by barrier element array **2504** to form a plurality of images in a viewing space **2526**, including a first image **2506***a* at a first location **2508***a* and a second image **2506***b* at a second location **2508***b*. A portion of the light emanating from pixel array **2502** is blocked by blocking barrier elements **2510**,

while another portion of the light emanating from pixel array **2502** passes through non-blocking barrier elements **2512**, according to the filtering by barrier element array **2504**. For instance, light **2524***a* from pixel **2514***a* is blocked by blocking barrier element **2510***a*, and light **2524***b* and light **2524***c* from pixel **2514***b* are blocked by blocking barrier elements **2510***b* and **2510***c*, respectively. In contrast, light **2518***a* from pixel **2514***a* is passed by non-blocking barrier element **2512***a* and light **2518***b* from pixel **2514***b* is passed by non-blocking barrier element **2512***b*.

**[0168]** By forming parallel non-blocking slits in a barrier element array, light from a pixel array can be filtered to form multiple images or views in a viewing space. For instance, system **2500** shown in FIG. **25** is configured to form first and second images **2506***a* and **2506***b* at locations **2508***a* and **2508***b*, respectively, which are positioned at a distance **2528** from pixel array **2502** (as shown in FIG. **25**, further instances of first and second images **2506***a* and **2506***b* may be formed in viewing space **2526** according to system **2500**, in a repeating, alternating fashion). As described above, pixel array **2502** includes a first set of pixels **2514***a*-**2514***d* and a second set of pixels **2516***a*-**2516***d*. Pixels **2514***a*-**2514***d* correspond to first image **2506***a* and pixels **2516***a*-**2516***d* correspond to second image **2506***b*. Due to the spacing of pixels **2514***a*-**2514***d* and **2516***a*-**2516***d* in pixel array **2502**, and the geometry of non-blocking barrier elements **2512** in barrier element array **2504**, first and second images **2506***a* and **2506***b* are formed at locations **2508***a* and **2508***b*, respectively. As shown in FIG. **25**, light **2518***a*-**2518***d* from the first set of pixels **2514***a*-**2514***d* is focused at location **2508***a* to form first image **2506***a* at location **2508***a*. Light **2520***a*-**2520***d* from the second set of pixels **2516***a*-**2516***d* is focused at location **2508***b* to form second image **2506***b* at location **2508***b*.

**[0169]** FIG. **25** shows a slit spacing **2522** (center-to-center) of non-blocking barrier elements **2512** in barrier element array **2504**. Spacing **2522** may be determined to select locations for parallel non-blocking slits to be formed in barrier element array **2504** for a particular image distance **2528** at which images are desired to be formed (for viewing by users). For example, in an embodiment, if a spacing of pixels **2514***a*-**2514***d* corresponding to an image is known, and a distance **2528** at which the image is desired to be displayed is known, the spacing **2522** between adjacent parallel non-blocking slits in barrier element array **2504** may be selected.

**[0170]** First and second images **2506***a* and **2506***b* are configured to be perceived by a user as a three-dimensional image or view. For example, a viewer may receive first image **2506***a* at a first eye location and second image **2506***b* at a second eye location, according to an exemplary embodiment. First and second images **2506***a* and **2506***b* may be generated by first set of pixels **2514***a*-**2514***d* and second set of pixels **2516***a*-**2516***d* as images that are slightly different perspective from each other. Images **2506***a* and **2506***b* are combined in the visual center of the brain of the viewer to be perceived as a three-dimensional image or view. In such an embodiment, first and second images **2506***a* and **2506***b* may be formed by display system **2500** such that their centers are spaced apart a width of a user's pupils (e.g., an "interocular distance").

**[0171]** Note that in the embodiments of FIGS. **26** and **27**, the entire regions of parallax barriers **2600** and **2700** are filled with parallel non-blocking strips (e.g., as shown for barrier element array **2602** in FIGS. **26** and **27**) to be configured to deliver three-dimensional images to viewing space **2270**. In further embodiments, one or more regions of a parallax barrier may be filled with parallel non-blocking strips to deliver three-dimensional images, and one or more other regions of the parallax barrier may be transparent to deliver two-dimensional images. Furthermore, different regions of a parallax barrier that have parallel non-blocking strips may have the parallel non-blocking strips oriented at different angles to deliver three-dimensional images to viewers that are oriented differently.

**[0172]** For instance, FIG. **28** shows a view of a parallax barrier **2800** configured to enable the simultaneous display of two-dimensional and three-dimensional images at different regions, according to exemplary embodiments. Parallax barrier **2800** is similar to parallax barrier **2600** of FIG. **26**, having barrier element array **2602** including a plurality of barrier elements **2604** arranged in a two-dimensional array. In FIG. **28**, a first region **2802** of barrier element array **2602** includes a plurality of parallel non-blocking strips alternated with parallel blocking strips that together fill first region **2802**. A second region **2804** of barrier element array **2602** is surrounded by first region **2802**. Second region **2804** is a rectangular shaped region of barrier element array **2602** that includes a two-dimensional array of barrier elements **2604** that are non-blocking. Thus, in FIG. **28**, barrier element array **2602** is configured to enable a three-dimensional image to be generated by pixels of a pixel array that are adjacent to barrier elements of first region **2802**, and to enable a two-dimensional image to be generated by pixels of the pixel array that are adjacent to barrier elements inside of second region **2804**. Note that alternatively, first region **2802** may include all non-blocking barrier elements **2602** to pass a two-dimensional image, and second region **2804** may include parallel non-blocking strips alternated with parallel blocking strips to pass a three-dimensional image. In further embodiments, parallax barrier **2800** may have additional numbers, sizes, and arrangements of regions configured to pass different combinations of two-dimensional images and three-dimensional images.

**[0173]** In another example, FIG. **29** shows a view of a parallax barrier **2900** with transparent slits having different orientations, according to an exemplary embodiment. Parallax barrier **2900** is similar to parallax barrier **2600** of FIG. **26**, having barrier element array **2602** including a plurality of barrier elements **2604** arranged in a two-dimensional array. A first region **2910** (e.g., a bottom half) of barrier element array **2602** includes a first plurality of parallel strips of barrier elements **2604** that are selected to be non-blocking to form a first plurality of parallel non-blocking strips **2902***a*-**2902***e* (each having a width of two barrier elements **2604**). As shown in FIG. **29**, parallel non-blocking strips **2902***a*-**2902***e* are alternated with parallel blocking strips **2904***a*-**2904***f* of barrier elements **2604** (each having a width of three barrier elements **2604**). Parallel non-blocking strips **2902***a*-**2902***e* are oriented in a first direction (e.g., along a vertical axis).

**[0174]** Furthermore, as shown in FIG. **29**, a second region **2912** (e.g., a top half) of barrier element array **2602** includes a second plurality of parallel strips of barrier elements **2604** that are selected to be non-blocking to form a second plurality of parallel non-blocking strips **2906***a*-**2906***d* (each having a width of one barrier element **2604**). As shown in FIG. **29**, parallel non-blocking strips **2906***a*-**2906***d* are alternated with parallel blocking strips **2908***a*-**2908***c* of barrier elements **2604** (each having a width of two barrier elements **2604**). Parallel non-blocking strips **2906***a*-**2906***d* are oriented in a second direction (e.g., along a horizontal axis).

**[0175]** As such, in FIG. **29**, first and second pluralities of parallel non-blocking strips **2902***a*-**2902***e* and **2906***a*-**2906***d* are present in barrier element array **2602** that are oriented perpendicularly to each other. The region of barrier element array **2602** that includes first plurality of parallel non-blocking strips **2902***a*-**2902***e* may be configured to deliver a three-dimensional image in a viewing space (as described above) to be viewable by a user whose body is oriented vertically (e.g., sitting upright or standing up). The region of barrier element array **2602** that includes second plurality of parallel non-blocking strips **2906***a*-**2906***d* may be configured to deliver a three-dimensional image in a viewing space (as described above) to be viewable by a user whose body is oriented horizontally (e.g., laying down). In this manner, users who are oriented differently relative to each other can still each be provided with a corresponding three-dimensional image that accommodates their position.

**[0176]** As described above, in an embodiment, display device **2102** of FIG. **21** may be configured to generate a two-dimensional image for viewing by users in a viewing space. For instance, referring to FIGS. **22** and **23**, barrier element array **2210** may be configured into a third configuration to deliver a two-dimensional view. In the third configuration, barrier array driver circuit **2206** may generate drive signal **2216** to configure each barrier element of barrier element array **2210** to be in the non-blocking state (transparent). If barrier element array **2210** is non-blocking, barrier element array **2210** functions as an "all pass" filter to substantially pass all of light **2252** (FIG. **22**) or light **2338** (FIG. **23**) as filtered light **2272** to deliver the two-dimensional image to viewing space **2270**, to be viewable as a two-dimensional image in a similar fashion as a conventional display.

**[0177]** In embodiments, display systems may be configured to generate multiple two-dimensional images or views for viewing by users in a viewing space. For example, FIG. **30** shows a display system **3000** configured to deliver two two-dimensional images, according to an embodiment. Display system **3000** is configured similarly to display system **2500** of FIG. **25**. As shown in FIG. **30**, display system **3000** includes pixel array **2502** and barrier element array **2504**, which generate first and second images **3002***a* and **3002***b*. As shown in FIG. **30**, a first viewer **3004***a* receives first image **3002***a* at a first location and a second viewer **3004***b* receives second image **3002***b* at a second location, according to an exemplary embodiment. Similarly to the description provided above with respect to FIG. **25**, first and second images **3002***a* and **3002***b* may be generated by first set of pixels **2514***a*-**2514***d* and second set of pixels **2516***a*-**2516***d* of pixel array **2502**. However, rather than first and second images **3002***a* and **3002***b* being images that are of different perspective, first and second images **3002***a* and **3002***b* are each a two-dimensional image that may be viewed independently from each other. For instance, image **3002***a* and image **3002***b* may generated by display system **2500** from first media content and second media content, respectively, that are independent of each other. Image **3002***a* may be received by both eyes of first viewer **3004***a* to be perceived by first viewer **3004***a* as a first two-dimensional image, and image **3002***b* may be received by both eyes of second viewer **3004***b* to be perceived by second viewer **3004***b* as a second two-dimensional image. Thus, first and second images **3002***a* and **3002***b* may be generated to have a spacing that enables them to be separately viewed by first and second users **3004***a* and **3004***b*.

**[0178]** As such, display system **3000** of FIG. **30** can be configured to deliver a single three-dimensional view to a viewer (e.g., as shown in FIG. **25** for display system **2500**), to deliver a pair of two-dimensional views to a pair of viewers (e.g., as shown in FIG. **30**), or to deliver a pair of three-dimensional views to a pair of viewers as described above). Display system **3000** can be configured to switch between delivering views to one and two viewers by turning off or turning on, respectively, the display of media content by pixel array **2502** associated with one of the viewers (e.g., by turning off or on pixels **2516** associated with second image **3002***b*). Display system **3000** can be configured to switch between delivering two-dimensional and three-dimensional views by providing the corresponding media content type at pixel array **3002**. Furthermore, display system **3000** may provide such capabilities when configured similarly to display system **2300** shown in FIG. **23** (e.g., including backlighting **2316**).

**[0179]** In an embodiment, display system **2500** may be configured to generate multiple three-dimensional images that include related image content (e.g., each three-dimensional image is a different viewpoint of a common scene), or that each include unrelated image content, for viewing by users in a viewing space. Each of the three-dimensional images may correspond to a pair of images generated by pixels of the pixel array. The barrier element array filters light from the pixel array to form the image pairs in a viewing space to be perceived by users as three-dimensional images.

**[0180]** For instance, FIG. **31** shows a flowchart **3100** for generating multiple three-dimensional images, according to an exemplary embodiment. Flowchart **3100** is described with respect to FIG. **32**, which shows a cross-sectional view of a display system **3200**. Display system **3200** is an exemplary embodiment of system **2200** shown in FIG. **22**, and is shown for purposes of illustration. As shown in FIG. **32**, system **3200** includes a pixel array **3202** and a barrier element array **3204**. System **3200** may also include display driver circuit **2202** of FIG. **22**, which is not shown in FIG. **32** for ease of illustration. Further structural and operational embodiments will be apparent to persons skilled in the relevant art(s) based on the discussion regarding flowchart **3100**. Flowchart **3100** is described as follows.

**[0181]** Flowchart **3100** begins with step **3102**. In step **3102**, light is received from an array of pixels that includes a plurality of pairs of sets of pixels. For instance, in the example of FIG. **32**, pixel array **3202** includes a first set of pixels **3214***a*-**3214***d*, a second set of pixels **3216***a*-**3216***d*, a third set of pixels **3218***a*-**3218***d*, and a fourth set of pixels **3220***a*-**3220***d*. Each of pixels **3214***a*-**3214***d*, **3216***a*-**3216***d*, **3218***a*-**3218***d*, **3220***a*-**3220***d* generates light, which emanates from the surface of pixel array **3202** towards barrier element array **3204**. Each set of pixels generates a corresponding image. First set of pixels **3214***a*-**3214***d* and third set of pixels **3218***a*-**3218***d* are configured to generate images that combine to form a first three-dimensional image. Second set of pixels **3216***a*-**3216***d* and fourth set of pixels **3220***a*-**3220***d* are configured to generate images that combine to form a second three-dimensional image. Pixels of the four sets of pixels are alternated in pixel array **3202** in the order of pixel **3214***a*, pixel **3216***a*, pixel **3218***a*, pixel **3220***a*, pixel **3214***b*, pixel **3216***b*, etc. Further pixels may be included in each set of pixels in pixel array **3202** that are not visible in FIG. **32**, including hundreds, thousands, or millions of pixels in each set of pixels.

**[0182]** As described above, in the current embodiment, pixel array **3202** is segmented into a plurality of pairs of sets

of pixels. For instance, in the example of FIG. **32**, pixel array **3202** is segmented into four sets of pixels. The first set of pixels includes pixels **3214***a*-**3214***g* and the other pixels in the same columns, the second set of pixels includes pixels **3216***a*-**3216***g* and the other pixels in the same columns, pixels **3218***a*-**3218***g* and the other pixels in the same columns, and pixels **3220***a*-**3220***g* and the other pixels in the same columns.

**[0183]** In step **3104**, a plurality of strips of barrier elements of a barrier element array is selected to be non-blocking to form a plurality of parallel non-blocking slits. As shown in FIG. **32**, barrier element array **3204** includes barrier elements that are each either non-blocking or blocking. Barrier elements that are blocking are indicated as barrier elements **3210***a*-**3210***f*, and barrier elements that are non-blocking are indicated as barrier elements **3212***a*-**3212***e*. Further barrier elements may be included in barrier element array **3204** that are not visible in FIG. **32**, including hundreds, thousands, or millions of barrier elements, etc. Each of barrier elements **3210***a*-**3210***f* and **3212***a*-**3212***e* may include one or more barrier elements. Barrier elements **3210** alternate with barrier elements **3212**. In this manner, blocking barrier elements **3210** are alternated with non-blocking barrier elements **3212** to form a plurality of parallel non-blocking slits in barrier element array **3204**.

**[0184]** In step **3106**, the light is filtered at the barrier element array to form a plurality of pairs of images in a viewing space corresponding to the plurality of pairs of sets of pixels, each pair of images of the plurality of pairs of images being configured to be perceived as a corresponding three-dimensional image of a plurality of three-dimensional images. As shown in FIG. **32**, light emanating from pixel array **3202** is filtered by barrier element array **3204** to form a plurality of images in a viewing space **3226**. For instance, four images are formed in viewing space **3226**, including first-fourth images **3206***a*-**3206***d*. Pixels **3214***a*-**3214***d* correspond to first image **3206***a*, pixels **3216***a*-**3216***d* correspond to second image **3206***b*, pixels **3218***a*-**3218***d* correspond to third image **3206***c*, and pixels **3220***a*-**3220***d* correspond to fourth image **3206***d*. As shown in FIG. **32**, light **3222***a*-**3222***d* from the first set of pixels **3214***a*-**3214***d* forms first image **3206***a*, and light **3224***a*-**3224***d* from the third set of pixels **3218***a*-**3218***d* forms third image **3206***c*, due to the filtering of the non-blocking slits (corresponding to non-blocking barrier elements **3212***a*-**3212***e*) in barrier element array **3204**. Although not indicated in FIG. **32** (for ease of illustration), in a similar fashion, light from the second set of pixels **3216***a*-**3216***d* forms second image **3206***b*, and light from the fourth set of pixels **3220***a*-**3220***d* forms fourth image **3206***d*.

**[0185]** In the embodiment of FIG. **32**, any pair of images of images **3206***a*-**3206***d* may be configured to be perceived as a three-dimensional image by a user in viewing space **3226**. For instance, first and third images **3206***a* and **3206***c* may be configured to be perceived by a user as a first three-dimensional image, such that first image **3206***a* is received at a first eye location and third image **3206***c* is received at a second eye location of a user. Furthermore, second and fourth images **3206***b* and **3206***d* may be configured to be perceived by a user as a second three-dimensional image, such that second image **3206***b* is received at a first eye location and fourth image **3206***d* is received at a second eye location of a user.

**[0186]** In the example of FIG. **32**, two three-dimensional images are provided by system **3200**. In further embodiments, further numbers of three-dimensional images may be provided, including a third three-dimensional image, a fourth three-dimensional image, etc. In such case, each three-dimensional image is generated by filtering light (using a barrier element array) corresponding to an image pair generated by a corresponding pair of sets of pixels of the pixel array, in a similar fashion as described with respect to FIG. **32** for two three-dimensional images. For example, to provide three three-dimensional images, pixel array **3202** may include fifth and sixth sets of pixels that generate fifth and sixth images, respectively, to be perceived by a user as a third three-dimensional image. To provide a fourth three-dimensional image, pixel array **3202** may include seventh and eighth sets of pixels that generate seventh and eighth images, respectively, to be perceived by a user as the fourth three-dimensional image.

**[0187]** In FIG. **32**, the first and second three-dimensional images generated based on first and third images **3206***a* and **3206***c* and second and fourth images **3206***b* and **3206***d*, respectively, and any further three-dimensional images that may be generated, may include related image content or may each include unrelated image content. For example, in an embodiment, the first and second three-dimensional images (and any further three-dimensional images) may have been captured as different viewpoints of a common scene. Thus, a user in viewing space **3226** that moves laterally to sequentially view the first and second three-dimensional images (and any further three-dimensional images) may perceive being able to partially or fully "view behind" objects of the common scene.

**[0188]** Further description regarding using a parallax barrier to deliver three-dimensional views, including adaptable versions of parallax barriers, is provided in pending U.S. patent application Ser. No. 12/845,409, titled "Display With Adaptable Parallax Barrier," in pending U.S. patent application Ser. No. 12/845,440, titled "Adaptable Parallax Barrier Supporting Mixed 2D And Stereoscopic 3D Display Regions," and in pending U.S. patent application Ser. No. 12/845,461, titled "Display Supporting Multiple Simultaneous 3D Views," which are each incorporated by reference herein in their entireties.

### 2. Exemplary Embodiments Using Lenticular Lenses

**[0189]** In embodiments, as described herein, display devices **2000** and **2100** of FIGS. **20** and **21** may include one or more lenticular lenses as light manipulators **2004** and **2104** used to deliver three-dimensional images and/or two-dimensional images. For instance, display systems **2200** and **2300** of FIGS. **22** and **23** may each include a sub-lens array of a lenticular lens in place of parallax barrier **2220**. For example, FIG. **33** shows a perspective view of a lenticular lens **3300** in accordance with an embodiment. As shown in FIG. **33**, lenticular lens **3300** includes a sub-lens array **3302**. Sub-lens array **3302** includes a plurality of sub-lenses **3304** arranged in a two-dimensional array (e.g., arranged side-by-side in a row). Each sub-lens **3304** is shown in FIG. **33** as generally cylindrical in shape and having a substantially semi-circular cross-section, but in other embodiments may have other shapes. In FIG. **33**, sub-lens array **3302** is shown to include eight sub-lenses for illustrative purposes and is not intended to be limiting. For instance, sub-lens array **3302** may include any number (e.g., hundreds, thousands, etc.) of sub-lenses **3304**. FIG. **34** shows a side view of lenticular lens **3300**, oriented as lenticular lens **3300** may be positioned in system **2500** of FIG. **25** (in place of parallax barrier **2504**) for lenticular lens **2502** to deliver three-dimensional views. In FIG.

34, light may be passed through lenticular lens **3300** in the direction of dotted arrow **3402** to be diverted.

**[0190]** In one embodiment, lenticular lens **3300** may be fixed in size. For example, light manipulator **2004** of FIG. **20** may include lenticular lens **3300** when fixed in size. In another embodiment, lenticular lens **3300** may be adaptable. For instance, light manipulator **2104** of FIG. **21** may include lenticular lens **3300** when adaptable. For instance, in an embodiment lenticular lens **3300** may be made from an elastic material. Such a lenticular lens **3300** may be adapted in size in response to generated drive signals.

**[0191]** Further description regarding using a lenticular lens to deliver three-dimensional views, including adaptable versions of lenticular lenses, is provided in pending U.S. patent application Ser. No. 12/774,307, titled "Display with Elastic Light Manipulator," which is incorporated by reference herein in its entirety.

### 3. Exemplary Embodiments Using Multiple Light Manipulators

**[0192]** Display devices **2000** and **2100** may include multiple layers of light manipulators in embodiments. Multiple three-dimensional images may be displayed in a viewing space using multiple light manipulator layers, according to embodiments. In embodiments, the multiple light manipulating layers may enable spatial separation of the images. For instance, in such an embodiment, for example, a display device that includes multiple light manipulator layers may be configured to display a first three-dimensional image in a first region of a viewing space (e.g., a left-side area), a second three-dimensional image in a second region of the viewing space (e.g., a central area), a third three-dimensional image in a third region of the viewing space (e.g., a right-side area), etc. In embodiments, a display device may be configured to display any number of spatially separated three-dimensional images, as desired for a particular application (e.g., according to a number and spacing of viewers in the viewing space, etc.).

**[0193]** For instance, FIG. **35** shows a flowchart **3500** for generating multiple three-dimensional images using multiple light manipulator layers, according to an exemplary embodiment. Flowchart **3500** is described with respect to FIG. **36**, which shows a cross-sectional view of a display system **3600** that includes multiple light manipulator layers, according to an exemplary embodiment. As shown in FIG. **36**, system **3600** includes a display driver circuit **3602**, an image generator **2212**, a first light manipulator **3614***a*, and a second light manipulator **3614***b*. As shown in FIG. **36**, image generator **2212** includes pixel array **2208**, first light manipulator **3614***a* includes first light manipulator elements **3616***a*, and second light manipulator **3614***b* includes second light manipulator elements **3616***b*. Furthermore, as shown in FIG. **36**, display driver circuit **3602** includes a pixel array driver circuit **3604** and a light manipulator driver circuit **3606**. Flowchart **3500** and system **3600** are described as follows.

**[0194]** Flowchart **3500** begins with step **3502**. In step **3502**, light is received from an array of pixels that includes a plurality of pairs of sets of pixels. For example, as shown in FIG. **36**, light **2252** is received at first light manipulator **3614***a* from pixel array **208** of image generator **2212**. Pixel array driver circuit **3604** may generate driver signals based on content signal **2224** received by display driver circuit **3602**, and the driver signals may be received by pixel array **2214** to generate light **2252**. Each pixel of pixel array **2208** may generate light that is received at first light manipulator **3614***a*. In an embodiment, pixel array driver circuit **3604** may generate drive signal **2214** to cause pixel array **2208** to emit light **2252** containing a plurality of images corresponding to the sets of pixels.

**[0195]** In step **3504**, the light from the array of pixels is manipulated with a first light manipulator. For example, first light manipulator **3614***a* may be configured to manipulate light **2252** received from pixel array **2208**. As shown in FIG. **36**, first light manipulator **3614***a* includes light manipulator elements **3616***a* configured to perform manipulating (e.g., filtering, diverting, etc.) of light **2252** to generate manipulated light **2272**. Light manipulator elements **3616***a* may optionally be configurable to adjust the manipulating performed by first light manipulator **3614***a*. First light manipulator **3614***a* may perform filtering in a similar manner as a parallax barrier described above or in other manner. In another embodiment, first light manipulator **3614***a* may include a lenticular lens that diverts light **2252** to perform light manipulating, generating manipulated light **2272**. In an embodiment, light manipulator driver circuit **3606** may generate drive signal **2216***a* based on control signal **2222** received by display driver **3602** to cause light manipulator elements **3616***a* to manipulate light **2252** as desired.

**[0196]** In step **3506**, the light manipulated by the first light manipulator is manipulated with a second light manipulator to form a plurality of pairs of images corresponding to the plurality of pairs of sets of pixels in a viewing space. For example, as shown in FIG. **36**, manipulated light **2272** is received by second light manipulator **3614***b* to generate manipulated light **3608** that includes a plurality of three-dimensional images **3610***a*-**3610***n* formed in viewing space **2270**. As shown in FIG. **36**, second light manipulator **3614***b* includes light manipulator elements **3616***b* configured to perform manipulating of manipulated light **2272** to generate manipulated light **3608**. Light manipulator elements **3616***b* may optionally be configurable to adjust the manipulating performed by second light manipulator **3614***b*. In an embodiment, light manipulator driver circuit **3606** may generate drive signal **2216***b* based on control signal **2222** to cause light manipulator elements **3616***b* to manipulate manipulated light **2252** to generate manipulated light **3608** including three-dimensional images **3610***a*-**3610***n* as desired. In embodiments, second light manipulator **3614***a* may include a parallax barrier or a lenticular lens configured to manipulate manipulated light **2252** to generate manipulated light **3608**.

**[0197]** As such, display system **3600** has a single viewing plane or surface (e.g., a plane or surface of pixel array **2208**, first light manipulator **3614***a*, second light manipulator **3614***b*) that supports multiple viewers with media content in the form of three-dimensional images or views. The single viewing plane of display system **3600** may provide a first three-dimensional view based on first three-dimensional media content to a first viewer, a second three-dimensional view based on second three-dimensional media content to a second viewer, and optionally further three-dimensional views based on further three-dimensional media content to further viewers. First and second light manipulators **3614***a* and **3614***b* each cause three-dimensional media content to be presented to a corresponding viewer via a corresponding area of the single viewing plane, with each viewer being enabled to view corresponding media content without viewing media content directed to other viewers. Furthermore, the areas of the single viewing plane that provide the various three-dimensional views of media content overlap each other at least

in part. In the embodiment of FIG. **36**, the areas may be the same area—an area of a display screen or surface of display system **3600**. As such, multiple three-dimensional views that are each viewable by a corresponding viewer may be delivered by a single display viewing plane.

**[0198]** Display system **3600** may be configured in various ways to generate multiple three-dimensional images according to flowchart **3500**, in embodiments. Furthermore, as described below, embodiments of display system **3600** may be configured to generate two-dimensional views, as well as any combination of one or more two-dimensional views simultaneously with one or more three-dimensional views.

**[0199]** For instance, in an embodiment, delivery of three-dimensional images may be performed in system **3600** using multiple parallax barriers. FIG. **37** shows a cross-sectional view of a display system **3700**, according to an exemplary embodiment. Display system **3700** is an example of system **3600** shown in FIG. **36**. As shown in FIG. **37**, system **3700** includes a pixel array **3702**, a first barrier element array **3704**, and a second barrier element array **3706**. System **3700** may also include display driver circuit **3602** of FIG. **36**, which is not shown in FIG. **37** for ease of illustration. System **3700** is described as follows.

**[0200]** As shown in the example of FIG. **37**, pixel array **3702** includes a first set of pixels **3714***a*-**3714***c*, a second set of pixels **3716***a*-**3716***c*, a third set of pixels **3718***a*-**3718***c*, and a fourth set of pixels **3720***a*-**3720***c*. Pixels of the four sets of pixels are alternated in pixel array **3702** in the order of pixel **3714***a*, pixel **3716***a*, pixel **3718***a*, pixel **3720***a*, pixel **3714***b*, pixel **3716***b*, etc. Further pixels may be included in each set of pixels in pixel array **3702** that are not visible in FIG. **37**, including hundreds, thousands, or millions of pixels in each set of pixels.

**[0201]** Each of pixels **3714***a*-**3714***c*, **3716***a*-**3716***c*, **3718***a*-**3718***c*, and **3720***a*-**3720***c* is configured to generate light, which emanates from the surface of pixel array **3702** towards first barrier element array **3704**. Each set of pixels is configured to generate a corresponding image. For example, FIG. **38** shows display system **3700**, where pixels of pixel array **3702** emit light. Light from second set of pixels **3716***a*-**3716***c* and first set of pixels **3714***a*-**3714***c* is configured to generate third and fourth images **3806***c* and **3806***d*, respectively, which may be perceived together as a second three-dimensional image by a second viewer **3004***b*. Light from fourth set of pixels **3720***a*-**3720***c* and third set of pixels **3718***a*-**3718***c* is configured to generate first and second images **3806***a* and **3806***b*, respectively, which may be perceived together as a first three-dimensional image by a first viewer **3004***a*. The light emitted by the sets of pixels is filtered by first and second barrier element arrays **3704** and **3706** to generate the first and second three-dimensional images in respective desired regions of a user space **3802** adjacent to display system **3700**.

**[0202]** First-fourth images **3806***a*-**3806***d* may be formed in viewing space **3802** at a distance from pixel array **3702** and at a lateral location of viewing space **3802** as determined by a configuration of display system **3700** of FIG. **37**, including a width and spacing of non-blocking slits in first barrier element array **3704**, by a width and positioning of non-blocking slits in second barrier element array **3706**, by a spacing between pixel array **3702** and first barrier element array **3704**, and a spacing between first and second barrier element arrays **3704** and **3706**.

**[0203]** In an embodiment, system **3600** of FIG. **36** may be configured similarly to display system **2300** of FIG. **23** to deliver three-dimensional images and/or two-dimensional images. For instance, in embodiments, system **3600** may include backlighting **2316** and pixel array **2322** separated by one or both of first and second light manipulators **3614***a* and **3614***b*. For example, FIG. **39** shows a block diagram of a display system **3900**, which is an example of display devices **2000** and **2100** shown in FIGS. **20** and **21**, according to an embodiment. Display system **3900** is configured to display multiple three-dimensional images in a viewing space in a spatially separated manner. As shown in FIG. **39**, system **3900** includes display driver circuit **3602**, backlighting **2316**, first light manipulator **3614***a*, second light manipulator **3614***b*, and pixel array **2322**. As shown in FIG. **39**, backlighting **2316** optionally includes light element array **2336**, first light manipulator **3614***a* includes first light manipulator elements **3616***a*, and second light manipulator **3614***b* includes second light manipulator elements **3616***b*. Furthermore, as shown in FIG. **39**, display driver circuit **3602** receives control signal **2222** and content signal **2224** and includes light source driver circuit **2330**, light manipulator driver circuit **3606**, and pixel array driver circuit **2328**. Light source driver circuit **2330**, light manipulator driver circuit **3606**, and pixel array driver circuit **2328** may generate drives signals to perform their respective functions based on control signal **2222** and/or content signal **2224**. As shown in FIG. **39**, first and second light manipulators **3614***a* and **3614***b* are positioned between backlighting **2316** and pixel array **2322**. In another embodiment, pixel array **2322** may instead be located between first and second light manipulators **3614***a* and **3614***b*.

**[0204]** As shown in FIGS. **22** and **23**, display driver circuit **2202** receives content signal **2224**, and as shown in FIGS. **36** and **39**, display driver circuit **3602** receives content signal **2224**. Content signal **2224** is an example of content signals **2008** and **2108** of FIGS. **20** and **21**. Content signal **2224** includes two-dimensional and/or three-dimensional content for display by the respective display devices/systems. For instance, display driver circuits **2202** and **3602** generate respective drive signals (e.g., pixel array drive signals) based on content signal **2224** to enable the content carried by content signal **2224** to be displayed.

### F. Example Display Environments

**[0205]** As described above, light manipulators may be reconfigured to change the locations of delivered views based on changing viewer positions. As such, a position of a viewer may be determined/tracked so that a parallax barrier and/or light manipulator may be reconfigured to deliver views consistent with the changing position of the viewer. For instance, with regard to a parallax barrier, a spacing, number, arrangement, and/or other characteristic of slits may be adapted according to the changing viewer position. With regard to a lenticular lens, a size of the lenticular lens may be adapted (e.g., stretched, compressed) according to the changing viewer position. In embodiments, a position of a viewer may be determined/tracked by determining a position of the viewer directly, or by determining a position of a device associated with the viewer (e.g., a device worn by the viewer, held by the viewer, sitting in the viewer's lap, in the viewer's pocket, sitting next the viewer, etc.).

**[0206]** Examples of display environments for display embodiments described herein include environments having a single viewer, as well as environments having multiple viewers. For example, in one type of environment (e.g., an office, living room, etc.), a single viewer interacts with an

electronic device, mobile or stationary, to view and/or interact with mixed 2D and 3D content, such as a mobile or desktop computer, smart phone, television, or other mobile or stationary device. It is noted that this type of environment may include more than one viewer. In another type of environment (e.g., a living room, a home theatre room, etc.), multiple viewers are enabled to interact with an electronic device, such as a television set (e.g., high-def, small screen, large screen, etc.), to view and/or interact with mixed 2D and 3D content in the form of television content, movies, video games, etc.

**[0207]** For instance, FIG. **40** shows a block diagram of a display environment **4000**, according to an exemplary embodiment. In the example of FIG. **40**, first and second viewers **4006***a* and **4006***b* are present in display environment **4000**, and are enabled to interact with a display device **4002** to be delivered two-dimensional and/or three-dimensional media content. Although two viewers **4006** are shown present in FIG. **40**, in other embodiments, other numbers of viewers **4006** may be present in display environment **4000** that may interact with display device **4002** and may be delivered media content by display device **4002**. As shown in FIG. **40**, display environment **4000** includes display device **4002**, a first remote control **4004***a*, a second remote control **4004***b*, a first headset **4012***a*, a second headset **4012***b*, and viewers **4006***a* and **4006***b*. Display device **4002** is an example of the display devices described above, and may be configured similarly to any display device described herein, including display device **606**. Viewer **4006***a* is delivered a view **4008***a* by display device **4002**, and viewer **4006***b* is delivered a view **4008***b* by display device **4002**. Views **4008***a* and **4008***b* may each be a two-dimensional view or a three dimensional view. Furthermore, in embodiments, view **4008***a* may be delivered to viewer **4006***a*, but not be visible by viewer **4006***b*, and view **4008***b* may be delivered to viewer **4006***b*, but not be visible by viewer **4006***a*.

**[0208]** Remote control **4004***a* is a device that viewer **4006***a* may use to interact with display device **4002**, and remote control **4004***b* is a device that viewer **4006***b* may use to interact with display device **4002**. For example, as shown in FIG. **40**, viewer **4006***a* may interact with a user interface of remote control **4004***a* to generate a display control signal **4014***a*, and viewer **4006***b* may interact with a user interface of remote control **4004***b* to generate a display control signal **4014***b*. Display control signals **4014***a* and **4014***b* may be transmitted to display device **4002** using wireless or wired communication links. Display control signals **4014***a* and **4014***b* may be configured to select particular content desired to be viewed by viewers **4006***a* and **4006***b*, respectively. For example, display control signals **4014***a* and **4014***b* may select particular media content to be viewed (e.g., television channels, video games, DVD (digital video discs) content, video tape content, web content, etc.). Display control signals **4014***a* and **4014***b* may select whether such media content is desired to be viewed in two-dimensional or three-dimensional form by viewers **4006***a* and **4006***b*, respectively. Remote controls **4004***a* and **4004***b* may be television remote control devices, game controllers, smart phones, or other remote control type device.

**[0209]** Headsets **4012***a* and **4012***b* are worn by viewers **4006***a* and **4006***b*, respectively.

**[0210]** Headsets **4012***a* and **4012***b* each include one or two speakers (e.g., earphones) that enable viewers **4006***a* and **4006***b* to hear audio associated with the media content of views **4008***a* and **4008***b*. Headsets **4012***a* and **4012***b* enable viewers **4006***a* and **4006***b* to hear audio of their respective media content without hearing audio associated the media content of the other of viewers **4006***a* and **4006***b*. Headsets **4012***a* and **4012***b* may each optionally include a microphone to enable viewers **4006***a* and **4006***b* to interact with display device **4002** using voice commands.

**[0211]** Display device **4002***a*, headset **4012***a*, and/or remote control **4004***a* may operate to provide position information **4010***a* regarding viewers **4006***a* to display device **4002**, and display device **4002***b*, headset **4012***b*, and/or remote control **4004***b* may operate to provide position information **4010***b* regarding viewers **4006***b* to display device **4002**. Display device **4002** may use position information **4010***a* and **4010***b* to reconfigure one or more light manipulators (e.g., parallax barriers and/or lenticular lenses) of display device **4002** to enable views **4008***a* and **4008***b* to be delivered to viewers **4006***a* and **4006***b*, respectively, at various locations. For example, display device **4002***a*, headset **4012***a*, and/or remote control **4004***a* may use positioning techniques to track the position of viewer **4006***a*, and display device **4002***b*, headset **4012***b*, and/or remote control **4004***b* may use positioning techniques to track the position of viewer **4006***b*.

### G. Example Electronic Device Implementations

**[0212]** Embodiments may be implemented in hardware, software, firmware, or any combination thereof For example, application(s) **104**, operating system **106**, operating system **400**, user input interface **402**, API **404**, kernel **406**, display driver interface **410**, display driver(s) **408**, application **604**, display driver **618**, first translator **1302**, second translator **1304**, boot loader **1810**, operating system **1812**, GUI generator **1902**, and/or boot up module **1904** may be implemented as computer program code configured to be executed in one or more processors.

**[0213]** For instance, FIG. **41** shows a block diagram of an example implementation of electronic device **4100**, according to an embodiment. In embodiments, electronic device **4100** may include one or more of the elements shown in FIG. **41**. As shown in the example of FIG. **41**, electronic device **4100** may include one or more processors (also called central processing units, or CPUs), such as a processor **4104**. Processor **4104** is connected to a communication infrastructure **4102**, such as a communication bus. In some embodiments, processor **4104** can simultaneously operate multiple computing threads.

**[0214]** Electronic device **4100** also includes a primary or main memory **4106**, such as random access memory (RAM). Main memory **4106** has stored therein control logic **4128**A (computer software), and data.

**[0215]** Electronic device **4100** also includes one or more secondary storage devices **4110**.

**[0216]** Secondary storage devices **4110** include, for example, a hard disk drive **4112** and/or a removable storage device or drive **4114**, as well as other types of storage devices, such as memory cards and memory sticks. For instance, electronic device **4100** may include an industry standard interface, such a universal serial bus (USB) interface for interfacing with devices such as a memory stick. Removable storage drive **4114** represents a floppy disk drive, a magnetic tape drive, a compact disk drive, an optical storage device, tape backup, etc.

**[0217]** As shown in FIG. **41**, secondary storage devices **4110** may include an operating system **4132**. Embodiments for operating system **4132** are described in detail above.

**[0218]** Removable storage drive **4114** interacts with a removable storage unit **4116**. Removable storage unit **4116** includes a computer useable or readable storage medium **4124** having stored therein computer software **4128**B (control logic) and/or data. Removable storage unit **4116** represents a floppy disk, magnetic tape, compact disk, DVD, optical storage disk, or any other computer data storage device. Removable storage drive **4114** reads from and/or writes to removable storage unit **4116** in a well known manner.

**[0219]** Electronic device **4100** further includes a communication or network interface **4118**. Communication interface **4118** enables the electronic device **4100** to communicate with remote devices. For example, communication interface **4118** allows electronic device **4100** to communicate over communication networks or mediums **4142** (representing a form of a computer useable or readable medium), such as LANs, WANs, the Internet, etc. Network interface **4118** may interface with remote sites or networks via wired or wireless connections.

**[0220]** Control logic **4128**C may be transmitted to and from electronic device **4100** via the communication medium **4142**.

**[0221]** Any apparatus or manufacture comprising a computer useable or readable medium having control logic (software) stored therein is referred to herein as a computer program product or program storage device. This includes, but is not limited to, electronic device **4100**, main memory **4106**, secondary storage devices **4110**, and removable storage unit **4116**. Such computer program products, having control logic stored therein that, when executed by one or more data processing devices, cause such data processing devices to operate as described herein, represent embodiments of the invention.

**[0222]** Devices in which embodiments may be implemented may include storage, such as storage drives, memory devices, and further types of computer-readable media. Examples of such computer-readable storage media include a hard disk, a removable magnetic disk, a removable optical disk, flash memory cards, digital video disks, random access memories (RAMs), read only memories (ROM), and the like. As used herein, the terms "computer program medium" and "computer-readable medium" are used to generally refer to the hard disk associated with a hard disk drive, a removable magnetic disk, a removable optical disk (e.g., CDROMs, DVDs, etc.), zip disks, tapes, magnetic storage devices, MEMS (micro-electromechanical systems) storage, nanotechnology-based storage devices, as well as other media such as flash memory cards, digital video discs, RAM devices, ROM devices, and the like. Such computer-readable storage media may store program modules that include computer program logic for application(s) **104**, operating system **106**, operating system **400**, user input interface **402**, API **404**, kernel **406**, display driver interface **410**, display driver(s) **408**, application **604**, display driver **618**, first translator **1304**, second translator **1304**, boot loader **1810**, operating system **1812**, GUI generator **1902**, boot up module **1904**, flowchart **500**, flowchart **800**, flowchart **1400**, flowchart **1600**, (including any one or more steps of flowcharts **500**, **800**, **1400**, and **1600**), and/or further embodiments of the present invention described herein. Embodiments of the invention are directed to computer program products comprising such logic (e.g., in the form of program code or software) stored on any computer useable medium. Such program code, when executed in one or more processors, causes a device to operate as described herein.

**[0223]** The invention can work with software, hardware, and/or operating system implementations other than those described herein. Any software, hardware, and operating system implementations suitable for performing the functions described herein can be used.

**[0224]** As described herein, electronic device **4100** may be implemented in association with a variety of types of display devices. For instance, electronic device **4100** may be one of a variety of types of media devices, such as a stand-alone display (e.g., a television display such as flat panel display, etc.), a computer, a game console, a set top box, a digital video recorder (DVR), other electronic device mentioned elsewhere herein, etc. Media content that is delivered in two-dimensional or three-dimensional form according to embodiments described herein may be stored locally or received from remote locations. For instance, such media content may be locally stored for playback (replay TV, DVR), may be stored in removable memory (e.g. DVDs, memory sticks, etc.), may be received on wireless and/or wired pathways through a network such as a home network, through Internet download streaming, through a cable network, a satellite network, and/or a fiber network, etc. For instance, FIG. **41** shows a first media content **4130**A that is stored in hard disk drive **4112**, a second media content **4130**B that is stored in storage medium **4124** of removable storage unit **4116**, and a third media content **4130**C that may be remotely stored and received over communication medium **4122** by communication interface **4118**. Media content **4130** may be stored and/or received in these manners and/or in other ways.

**[0225]** FIG. **42** shows a block diagram of a display system **4200** that supports mixed 2D, stereoscopic 3D and multi-view 3D displays according to an exemplary embodiment. As shown in FIG. **42**, display system **4200** includes media input interfaces **4202**, host processing circuitry **4204**, user input devices **4206**, display processing circuitry **4208**, adaptable display driver circuitry **4210**, adaptable 2D, 3Dx and mixed display **4212**, and first-third interface circuitry **4214**-**4218**. Host processing circuitry **4204** includes an operating system **4220** and application programs **4222**. Operating system **4220** includes user input interfaces **4220**, 2D, 3Dx and mixed display driver interface **4226**, shell operations **4228**, 2D, 3Dx, mixed 2D and 3Dx, and mixed 3Dx and 3Dy translation services **4230**, and API supporting regional 2D/3Dx **4232**. 2D, 3Dx and mixed display driver interface **4226** includes 2D only driver variant **4234**, 3Dx only driver variant **4236**, and mixed 2D and 3Dx driver variant **4238**. Display processing circuitry **4208** includes 2D, 3Dx, mixed 2D and 3Dx, and mixed 3Dx and 3Dy translation services **4240**.

**[0226]** Media input interfaces **4202** includes one or more media input interfaces, wired or wireless, for received media, such as those described elsewhere herein. For instance, media input interface **4202** may include an interface for receiving media content from a local media player device, such as a DVD player, a memory stick, a computer media player, etc., and may include commercially available (e.g., USB, HDMI, etc.) or proprietary interfaces for receiving local media content. Media input interface **4202** may include an interface for receiving media content from a remote source, such as the Internet, satellite, cable, etc.), and may include commercially available (e.g., WLAN, Data Over Cable Service Interface Specification (DOCSIS), etc.) or proprietary interfaces for receiving remote media content.

**[0227]** Host processing circuitry **4204** may include one or more integrated circuit chips and/or additional circuitry,

which may be configured to execute software/firmware, including operating system **4220** and application programs **4222**. Operating system **4220** is an example of OS **400** described herein. User input interfaces **4220** is an example of user input interfaces **420** of FIG. **4**B. 2D, 3Dx and mixed display driver interface **4226** is an example of 2D, 3Dx and mixed display driver interface **422** of FIG. **4**B. Shell operations **4228** is an example of shell operations **424** of FIG. **4**B. 2D, 3Dx, mixed 2D and 3Dx, and mixed 3Dx and 3Dy translation services **4230** is an example of 2D, 3Dx, mixed 2D and 3Dx, and mixed 3Dx and 3Dy translation services **426** of FIG. **4**B. API supporting regional 2D/3Dx **4232** is an example of API supporting regional 2D/3Dx **428** of FIG. **2**B. 2D only driver variant **4234** is an example of 2D only driver variant **434**, 3Dx only driver variant **4236** is an example of 3Dx only driver variant **436**, and mixed 2D and 3Dx driver variant **4238** is an example of mixed 2D and 3Dx driver variant **438** of FIG. **4**B.

**[0228]** User input devices **4206** includes one or more user input devices that a user may use to interact with display system **4200**. Examples of user input devices are described elsewhere herein, such as a keyboard, a mouse/pointer, etc.

**[0229]** Display processing circuitry **4208** may be included in host processing circuitry **4204**, or may be separate from host processing circuitry **4204** as shown in FIG. **42**. For instance, display processing circuitry **4208** may include one or more processors (e.g., graphics processors), further circuitry and/or other hardware, software, firmware, or any combination thereof Display processing circuitry **4208** may be present to perform graphics processing tasks. For instance, as shown in FIG. **42**, display processing circuitry **4208** may optionally include 2D, 3Dx, mixed 2D and 3Dx, and mixed 3Dx and 3Dy translation services **4240** to perform 2D/3D related translation services in addition or alternatively to translation services **4230**.

**[0230]** Adaptable display driver circuitry **4210** includes one or more display driver circuits for an adaptable display. Examples of adaptable display driver circuitry **4210** are described above, such as with regard to FIGS. **4**B, **22**, **23**, **36**, and **39**.

**[0231]** Adaptable 2D, 3Dx and mixed display **4212** includes a display that is adaptable, and is capable of displaying 2D content, 3D content, and a mixture of 2D and/or 3D content. Examples of adaptable 2D, 3Dx and mixed display **4212** are described elsewhere herein.

**[0232]** First-third interface circuitry **4214-4218** is optional. For instance, as shown in FIG. **42**, a communication infrastructure (e.g., a signal bus) **4234** may be present to couple signals of media input interfaces **4202**, host processing circuitry **4204**, user input devices **4206**, display processing circuitry **4208**, adaptable display driver circuitry **4210**, and display **4212**. In an embodiment, if display processing circuitry **4208**, adaptable display driver circuitry **4210**, and/or display **4212** are contained in a common housing/structure with host processing circuitry **4204** (e.g., in a handheld device, etc.) interface circuitry **4214-4218** may not be needed to be present. If display processing circuitry **4208**, adaptable display driver circuitry **4210**, and/or display **4212** are in a separate housing/structure from host processing circuitry **4204**, corresponding interface circuitry **4214-4218** may be present to provide an interface. For instance, host processing circuitry **4204** may be in a game console, a desktop computer tower, a home audio receiver, a set top box, etc., and display processing circuitry **4208**, adaptable display driver circuitry **4210**, and/or display **4212** may be included in a display device structure. In such case, interface circuitry **4214-4218** may not be present. When present, first-third circuitry **4214-4218** may each include circuitry, such as receivers and/or transmitters (wired or wireless), for enabling communications between the respective one of display processing circuitry **4208**, adaptable display driver circuitry **4210**, and display **4212**, and the other components of system **4200** (e.g., host processing circuitry **4204**, etc.).

**[0233]** Note that the embodiment of display system **4200** shown in FIG. **42** is provided for purposes of illustration, and is not intended to be limiting. In further embodiments, display system **4200** may include fewer, additional, and/or alternative features than shown in FIG. **42**.

## IV. Conclusion

**[0234]** While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

What is claimed is:

**1**. A method used in an operating system to support simultaneous display on a screen of both two-dimensional content and three-dimensional content, the method comprising:

receiving from a first application a first command directing display of the two-dimensional content within a first region of the screen;

responding to the first command by sending a first control signal that places the screen in a two-dimensional mode within the first region;

receiving from a second application a second command directing display of the three-dimensional content within a second region of the screen; and

responding to the second command by sending a second control signal that places the screen in a three-dimensional mode within the second region.

**2**. The method of claim **1**, further comprising receiving user input directing movement of the three-dimensional content from the second region of the screen to a third region of the screen, and sending a third control signal directing the movement via corresponding modifications to the screen.

**3**. The method of claim **1**, further comprising delivering three-dimensional content to a pixel array of the screen that corresponds with the second region of the screen in which an adaptable light manipulator of the screen is operating in the three-dimensional mode.

**4**. The method of claim **1**, wherein the first command and second command are part of an application program interface.

**5**. The method of claim **1**, further comprising:

receiving an input signal from a user input interface;

generating a third control signal in response to the input signal, the third control signal relating to a three-dimensional characteristic; and

delivering the third control signal to cause the adjustment of the three-dimensional characteristic of the three-dimensional content being displayed within the second region of the screen.

6. The method of claim 1, further comprising:
receiving an indication from the screen of whether the second control signal was successful;
generating a response to the second command based on the indication; and
providing the response to the second application.

7. The method of claim 6, wherein said providing comprises:
providing a window handle in the response to the second application, the window handle being a handle for a window opened in the second region to display the three-dimensional content.

8. The method of claim 1, wherein the second command includes one or more parameters, wherein said receiving comprises:
generating the second control signal to configure the screen based on the one or more parameters.

9. The method of claim 8, wherein the second command is configured to cause a window that displays the three-dimensional content to be opened in the second region.

10. The method of claim 8, wherein said generating comprises:
filtering out a parameter of the one or more parameters that is incompatible with the screen.

11. The method of claim 1, further comprising:
receiving a request from the second application for an indication of at least one characteristic of the screen; and
providing the requested indication of the at least one characteristic to the second application.

12. An operating system that supports a plurality of software applications and at least one of a plurality of screens, a first of the plurality of screens supporting at least three-dimensional display, and a second of the plurality of screens supporting at least two-dimensional display, the operating system comprising:
an application programming interface through which a first of the plurality of software applications can deliver at least one request that defines a first screen region and either a two-dimension indicator or a three-dimension indicator;
a display driver interface through which at least one configuration command corresponding to the at least one request is passed; and
a first display driver, associated with the first screen of the plurality of screens, that receives the at least one configuration command and responds by generating one or more screen control signals to adjust the first screen to support the first screen region of the first of the plurality of screens.

13. The operating system of claim 12, wherein the at least one configuration command causes the display driver to manipulate incoming pixel data before delivery to the plurality of screens.

14. The operating system of claim 12, further comprising a second display driver, associated with the second of the plurality of screens, that receives and responds to the at least one configuration command by translating incoming three-dimensional data to two-dimensional data for display on the second screen of the plurality of screens.

15. The operating system of claim 12, wherein the display driver is configured to receive an indication from the first screen of whether a screen control signal was successful, to generate a response to the at least one request that includes the indication, and to transmit the response to the first application via the application programming interface.

16. The operating system of claim 12, wherein a first request of the at least one request defines the first screen region, and includes the three-dimension indicator and one or more parameters.

17. The operating system of claim 16, wherein the first request is configured to cause a window that displays three-dimensional content to be opened in the first screen.

18. The operating system of claim 16, wherein the display driver interface is configured to filter out a parameter of the one or more parameters that is incompatible with the first screen.

19. The operating system of claim 16, wherein the first request is an open window command, and the one or more parameters includes at least one of a window size parameter, a window position parameter, a display resolution parameter, a window type parameter, a three-dimensional display type parameter, or a three-dimensional content source indication parameter.

20. The operating system of claim 12, further comprising:
a user input interface configured to receive a user input directed to three-dimensional content displayed in the first screen region, to generate a second configuration command based on the user input, the second configuration command being configured to adjust a three-dimensional characteristic of three-dimensional content displayed by the first screen region, the display driver interface being configured to pass the second configuration to the first display driver, the first display driver receiving the generated configuration command and generating a screen control signal to adjust the three-dimensional characteristic of the three-dimensional content being displayed within the first screen region.

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